tudies on Insects Affecting the Fruit of the Apple

With Particular Reference to the Characteristics of the Resulting Scars

A THESIS

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL OF CORNELL UNIVERSITY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

BY

HARRY HAZELTON KNIGHT

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CONTENTS

STUDIES ON INSECTS AFFECTING THE FRUIT OF THE APPLE, WITH PARTICULAR REFERENCE TO THE CHARACTERISTICS OF THE RESULTING SCARS[1]

Harry Hazelton Knight

During the season of 1914 the writer began an extensive series of observations on the production and development of scars induced by the various insects attacking the apple. The ultimate aim of this work was to make it possible to determine from the characters of the scars on the apples at picking time what insects had caused them, so that the orchardist might deal more intelligently with these obscure foes. The writer was able to carry on this work under most favorable circumstances in cooperation with the Genesee County Fruit Growers' Association, spending all his time during four growing seasons in orchards throughout Genesee County. Extensive data were obtained on the scars and blemishes caused by all of the well-known injurious insects affecting the fruit of the apple, and detailed observations and photographs were made of the work of several species that are scarcely to be recognized from the scars they produce. New and little-known types of scars were studied, particularly those caused by the apple redbugs *Lygidea mendax* and *Heterocordylus malinus*. The scars caused by these bugs were found to develop differently according to the variety of apple affected and the time of puncture with reference to the growth of the fruit. Several species of lepidopterous larvae are known to injure the fruit of the apple, and comparative studies were made of fifteen different species and photographs were obtained showing the chief characteristics of their work and the resulting scars. In all, thirty species of insects, representing five orders, were found attacking the fruit of the apple in western New York, and comparative studies show that with sufficient observation and experience a large proportion of all the blemishes and scars found on apples at picking time may be correctly referred to the insects causing them. Comparative studies with an extensive series of photographs were made of the scars and blemishes caused by agencies other than insects, particularly by spray injury, mechanical injuries, apple scab, frost, and hailstones.

[1] Also presented to the Faculty of the Graduate School of Cornell University, June, 1920, as a thesis in partial fulfillment of the requirements for the degree of doctor of philosophy.

INSECTS STUDIED

The species of insects studied were the following:

Hemiptera:

1. The light apple redbug (*Lygidea mendax* Reuter)
2. The dark apple redbug (*Heterocordylus malinus* Reuter)
3. The colon apple leaf bug (*Paracalocoris hawleyi pallidulus* McAtee)
4. The clouded apple leaf bug (*Neurocolpus nubilus* Say)
5. The rosy apple aphid (*Aphis sorbi* Kaltenbach)
6. The apple leaf aphid (*Aphis pomi* De Geer)
7. The San José scale (*Aspidiotus perniciosus* Comstock)
8. The oyster-shell scale (*Lepidosaphes ulmi* Linnaeus)
9. The scurfy scale (*Chionaspis furfura* Fitch)

Lepidoptera:

1. The codling moth (*Carpocapsa pomonella* Linnaeus)
2. The lesser apple worm (*Enarmonia prunivora* Walsh)
3. The fruit-tree leaf roller (*Archips argyrospila* Walker)
4. The oblique-banded leaf roller (*Archips rosaceana* Harris)
5. The green fruit worm (*Xylina antennata* Walker)
6. The green fruit worm (*Xylina laticinerea* Grote)
7. The red fruit worm (*Rhynchagrotis placida* Grote)
8. The white-marked tussock moth (*Hemerocampa leucostigma* Smith and Abbot)
9. The palmer worm (*Ypsolophus ligulellus* Hübner)
10. The bud moth (*Tmetocera ocellana* Schiffermüller)
11. The red-banded leaf roller (*Eulia velutinana* Walker)
12. The pistol case-bearer (*Coleophora malivorella* Riley)
13. The cigar case-bearer (*Coleophora fletcherella* Fernald)
14. The fall webworm (*Hyphantria textor* Harris)
15. The apple serpentine miner (*Marmara pomonella* Busck)

Coleoptera:

1. The plum curculio (*Conotrachelus nenuphar* Herbst)
2. The apple curculio (*Anthonomus quadrigibbus* Say)
3. The rose chafer (*Macrodactylus subspinosus* Fabricius)

Diptera:

1. The apple maggot (*Rhagoletis pomonella* Walsh)

Hymenoptera:

1. The apple-seed chalcis (*Syntomaspis druparum* Boheman)
2. The dock false-worm (*Ametastegia glabrata* Fallén)

METHODS OF STUDY

In conducting the observations, large shipping tags were used to keep track of the injured apples. On these tags were written all data regarding the time of injury, and subsequently additional notes were added concerning the development of the scars. Large numbers of apples were tagged for each species of insect found at work in the various orchards,

and at short intervals throughout the growing period specimens were picked and photographed so that a record might be kept of each kind of injury in its various stages of development. Where it was desirable to cage insects on the limb with the fruit — as, for example, to find what injuries a particular larva, nymph, or adult might produce, or to prevent other insects from adding scars to the experiment — a coarsely woven fabric called *tarlatan* was used for inclosing the limb and fruit. This material allows sunlight and rain to pass through readily, thus permitting normal growth, whereas the use of cheesecloth or other heavy and coarsely woven material was found to be detrimental to growth, causing the leaves to drop and the fruit to remain stunted.

For convenience in carrying out the photographic work, a small laboratory, equipped with dark room and skylight, was erected in one of the orchards (Plate III). Here the work was carried out to better advantage than would have been possible with the camera at some distant point. This laboratory consisted of a frame structure, 10 by 12 feet in area by 9 feet in height at the ridgepole, with sides screened and the roof covered with a light canvas except for one-half of the south exposure, which was fitted with glass to form a skylight. The dark room, 5 by 5 feet in area by 6 feet in height, occupied the rear corner opposite the operating table and skylight, and was made lightproof by several thicknesses of tar paper tacked over a framework containing a door with a passageway. A thick, dark ruby glass, set in one side as a window, furnished all the necessary lighting, thus completing a very simple but effective dark room.

GROWTH OF FRUIT IN RELATION TO TIME OF INJURY A FACTOR IN THE TYPE OF SCAR DEVELOPED

The amount of injury in an orchard as measured by the proportion of injured fruits at picking time, and the types of scars produced, depend on several factors. When there is a heavy set of fruit, it is always the weak and injured fruits that drop first; the fruits that get a strong start and are free from injury are the ones that survive. In years when there is a heavy set, therefore, the redbugs and the leaf-roller larvae may actually help to thin the fruit without leaving a noticeable proportion of scarred fruits, since it is the injured apples that drop in the thinning process. If the season is favorable to very rapid growth following the blooming period, a larger proportion of injured fruits will recover and grow to maturity than in a year when growth is slow following the bloom. In a year when there is a light set of fruit and the period of growth is favorable to rapid development, the conditions are right to produce the largest proportion of scarred fruit at picking time, since by forced growth many

weak and injured fruits are able to develop that otherwise would have dropped. Any condition that tends to force the growth of the tree will enable more of the injured and weak fruits to grow and recover. The writer soon learned to thin the fruit on the limbs on which he was tagging apples that were being injured by an insect; if this were not done, it was found that about 95 per cent of the fruits tagged would drop and the experiment would be lost.

Certain varieties of apples are more subject to fatal injury than are others. Apples that grow to a large size, such as the Twenty Ounce and the pippin varieties, develop rapidly and can withstand or recover from wounds such as would cause a slow-growing variety to drop. The Northern Spy is a variety that develops slowly following the set of the fruit, and thus the injured fruits are more likely to drop. Strong vitality in the development of the fruit is particularly noticeable in pippin and Twenty Ounce apples injured by larvae of the fruit-tree leaf roller. These fruits may have part of the core eaten out and still develop to maturity, showing the remains of the core tissue at the bottom of the wound.

It was found that different varieties of apples would develop different kinds of scars when attacked by the same insect, this being particularly true in the case of the apple redbugs. Fruits that are punctured when very small and growing rapidly develop a different type of scar from that produced on apples that are attacked at a more mature stage. If the core of the young apple is punctured by feeding redbugs, the flesh of the fruit never grows back at the point of puncture and a deep pit results in the mature apple (Plate IV, 4). Later, when the fruit is of such size that the insect is unable to reach the core, the flesh will develop beneath the point of puncture and tend to reduce the depth of the pit. When the growth is sufficiently rapid, the pit may disappear entirely and a spreading russet scar take its place. After the apples have reached more than a quarter of an inch in diameter, growth is very rapid, and the punctures made by redbugs cause a splitting of the fruit skin which continues to enlarge with the growth of the apple until broad russet scars result (Plates IV, 3, VII, 20 and 21, and VIII, 22). Wounds made later in the season do not heal so readily as do those made while the fruit is expanding by rapid growth early in the season. Wounds made after the middle of July never heal with a clean scar, but become covered with a thick, corky layer formed by the dead and dried cells of the fruit. In the case of these later injuries, which are usually produced by the tussock moth or the plum curculio, the maturing date of the variety has much to do with the healing of the wound. Early-maturing varieties do not heal the wounds made after growth is nearly completed, and in many cases brown rot results.

NATURE OF INJURIES CAUSED BY DIFFERENT SPECIES

HEMIPTERA

The order Hemiptera includes all of the true bugs, and in the present study all the hemipterous insects discussed come within the families Miridae, Aphididae, and Coccidae. The Hemiptera develop by gradual metamorphosis, and thus the nymphs, in their feeding habits and activities, are similar to the adults. Both nymph and adult puncture the fruit by means of a long proboscis and suck juices from the tender tissue. In most cases the injuries by the adult are little different from the work of the nymphs except in point of time, and any difference that may be noted is due to the difference in the stage of growth of the fruit as related to the time when the puncture is made.

The light apple redbug
(*Lygidea mendax* Reuter)

The nymphs of *Lygidea mendax* begin hatching just as the blossom buds separate at the tips, and most of them have entered the second instar by the time the blossom buds show pink and are ready for the first scab spray. The nymphs are in the third instar while the trees are in bloom, and most of them have entered the fourth stage by the time the petals have fallen. It is during the fourth and fifth instars that the greatest amount of damage is done, or from the time when the petals fall to the time when the young apples are one-half inch in diameter. In 1914, which was a normal growing season, the adults of *Lygidea mendax* were maturing rapidly by June 18, and practically all were mature by June 22. The adults feed on the fruits extensively for a week or more, and then, as the fruits get larger and become tough, they begin feeding more on the tender shoots that develop.

When the redbug nymphs first begin feeding on the young fruit, the tissue of the core is usually punctured. In a short time, however, the fruit has increased in size to such an extent that the insect's proboscis is no longer able to reach the core tissue. Redbug punctures that penetrate the core develop a very different type of scar from those made at a later period. When the core tissue is punctured, the fleshy part of the apple grows up around the point of puncture, leaving a deep pit where the injury occurred; this is shown in Plate V, 7, a photoghraph made ten weeks after the fruit was punctured. Such apples invariably develop deep-sunken pits, as shown in the mature Northern Spy apples in Plates V, 8, and VI, 12. Of the varieties observed by the writer, the Northern Spy is the slowest in developing size in the fruit, and thus a higher proportion of deeply pitted apples is found in that variety. The Rhode Island *Green-*

ing and the Baldwin apples develop more rapidly following the set of the fruit, and hence the time is shorter during which the insects may reach the core and produce the deep wounds; this results in a smaller proportion of deeply pitted apples (Plate V, 9) and a greater number of the russet-scar type.

The irregular russet scars that have been so little understood are developed from punctures made just after the apple has become too large for the insect to reach the core with its beak and while the fruit is growing rapidly. In Plate IV, 1, Rhode Island *Greening* fruits are shown with nymph and adult redbugs, at a time when the core may no longer be reached (June 18) but at a period when the feeding punctures will produce ultimately the peculiar russet scars shown in Plates IV, 3, VII, 20 and 21, and VIII, 22. These young apples (Plate IV, 1) show injuries produced by feeding punctures made on June 10 and 11. The smaller apple shows in two or three places that the core was penetrated when the bug inserted its proboscis, while the larger one had passed that stage before the injury was made. When the fruit is first punctured the sap runs out freely, this being followed by the development of a thick gelatinous covering to the wound the edges of which turn white after a few hours. In two or three days the wound becomes rusty brown, and if the apple is growing rapidly the skin splits and thus enlarges the wound (Plate V, 5 and 6). It is the late injuries, made when the apple is growing most rapidly, that spread into the broad, shallow, russet scars. In many cases, even when punctured early the apple recovers so completely that no depressions result and only the broad, irregular russet scars are seen (Plates IV, 3, VI, 13, and VIII, 22 and 23).

Northern Spy apples punctured by the feeding bugs between June 12 and 14 were photographed when examined on July 8, at which time the characteristic splitting of the skin was well developed about the wounds (Plate IV, 2). The condition of the apple shown in this figure is almost an exact duplication of the condition on July 8 of the Northern Spy apple shown in Plate IV, 3. The mature apple shows how the scars have run together and healed to such an extent that no depressions have been formed. Baldwin apples punctured between June 10 and 18 were examined on July 3, at which time they showed the characteristic splitting of the skin about each of the punctures. This condition is well illustrated in Plate V, 6. It is at this age that the scars very much resemble certain developments of apple scab (Plate VII, 18). In Plate VI, 14, is shown a Rhode Island *Greening* apple (photographed on July 7) in which the scars are just developing but will soon spread and take on a russet character. Red Astrachan apples, being an early variety, develop more

rapidly than do standards, and thus the scars on that fruit will have on a given date a more advanced character than on the Baldwin, Rhode Island *Greening,* and Roxbury apples.

Very soon after the adult bugs emerge, or by June 25 to 27, the apples have attained such size and the growth is so gradual that the punctures made by the bugs do not split and enlarge as do the punctures made earlier. In Plate VI, 10 and 11, is shown the effect of late feeding of adult bugs, which may result in mere dimples or in tiny russet spots, depending much on the variety affected. The spots on the apple shown in Plate VI, 10, resemble very closely the dimples caused by the deposition of eggs by the apple maggot fly; but if they were the work of the latter, a cross section of the puncture would show either where the egg was placed or the winding trail of the maggot leading from it. The work of the apple-seed chalcis (*Syntomaspis druparum*) may resemble the work of apple maggot flies or very late-feeding punctures of redbugs, but in injury by the chalcis the larvae of the fly may be found in the seeds or a careful section will show the slender, straight trail of the ovipositor leading to the seeds (Plate XXXIV, 142).

Roxbury and Golden Russet apples are subject to injury by redbugs. The pitted and russet types of injury resulting on Roxburys are shown in Plate VII, 19, while the work on Golden Russets (July 13) is shown in Plate VI, 15. The early injuries produce deep pits, while the latest punctures cause russet scars that may frequently be hard to distinguish from the normal appearance of those varieties. In Plate VIII, 23, is shown a mature Roxbury apple injured by fifth-stage nymphs between June 15 and June 18, on which the russet scars healed so evenly with the normal surface that the apple would probably have passed inspection as Grade A fruit. The Baldwin apple shown in Plate VIII, 22, is perfectly shaped, but it has the characteristic russet scars developed from the late-feeding punctures of redbugs. In Plate VII, 21, is shown a mature but stunted Baldwin apple, which recovered from injuries of the feeding bugs although the adjoining fruit was so badly punctured that it died and shriveled up but still clung to the tree. Scars from late feeding were observed on Bough apples, these being very similar to scars found on Champlain and other early varieties. Russet scars caused by redbug punctures on Detroit Red apples were found to be very conspicuous on the dark skin of that variety. The same type of scars is shown on St. Lawrence apples (Plate VI, 13), and in this case the original rough scars, noted in July, changed to a smooth, brassy surface on the mature fruit.

The appearance of redbug scars differs according to the variety and is most interesting in some of the unnamed apples. In Plate VII, 20, are

shown the very conspicuous russet scars produced on an unnamed variety having a light-colored transparent skin. Certain of the slow-growing natural fruits do not split about the wound and develop the enlarged scars that occur in varieties having more rapid growth. Typical stages of redbug work are seen on the young natural fruits shown in Plate VI, 16 (photographed on July 6). *Lygidea mendax* was found breeding also on quince, where the bugs feed on the fruits and produce typical scars (Plate IX, 27) which in some cases might be mistaken for the work of the quince curculio.

Numerous fruits were tagged in the process of following the work of redbugs on the several varieties of apples, and in a few cases photographs were made of the young injured apple on the tree and again when the fruit was mature.

Redbug injury combined with injury by the rosy aphid

Under certain conditions the rosy aphid (*Aphis sorbi*) may develop and feed on apples injured by redbugs. When this occurs, the scars started by the redbugs are much enlarged and otherwise changed by the aphids (Plate VIII, 24). The work of the rosy aphid on apples tends to stunt the fruit as well as to cause it to become badly misshapen. The redbug punctures affected by aphids develop a wound having an ugly white frothy scab, which may eventually heal and produce a badly gnarled fruit. In Plate VIII, 25, are shown two mature Rhode Island *Greening* apples which on June 25 appeared exactly as did the injured fruits shown in Plate VIII, 24.

Varieties of apples injured by Lygidea mendax

The varieties of apples most affected by *Lygidea mendax* in Genesee County are here given in the order of greatest injury suffered: Rhode Island *Greening*, Northern Spy, Baldwin, Roxbury, Tolman, Tompkins King, Maiden Blush, Twenty Ounce, Esopus, Fall Pippin.

The dark apple redbug
(*Heterocordylus malinus* Reuter)

The dark apple redbug (*Heterocordylus malinus*) develops from seven to ten days earlier than does *Lygidea mendax*, and this makes considerable difference in its ability to injure apples. The nymphs hatch with the unfolding of the leaves, and feed on the tender foliage and to a slight extent on the fruit before reaching maturity. In a few cases the adult bugs have been observed to feed on the fruit, but all fruits so attacked dropped within a short time. It is apparent that in the case of most

varieties of apples the insects have practically finished feeding before the fruit is large enough to withstand the injuries of the bugs and remain on the trees; therefore, most of the injured fruits drop, and very few reach maturity with their scars.

In trying to get definite data on the work of this species, the writer carried out in 1915 no less than forty experiments, each of which consisted of isolating two fourth- or fifth-stage nymphs on an apple branch which was blooming and setting fruit. This was accomplished by using, as cages, bags made of tarlatan, which were drawn up around the limb and firmly tied. The nymphs invariably preferred to feed on the tender foliage instead of on the fruit. The few fruits that were punctured by the bugs did not survive the June drop and thus were lost.

The adults of this species (Plate IX, 26) are mature and have begun to lay eggs by the time the fruit is large enough to be injured, and thus their opportunity for doing harm is not so great as is that of *Lygidea mendax*. Redbug injury on Twenty Ounce apples which developed on a tree infested by *Heterocordylus malinus* and which the writer believes to be the work of that species, is shown in Plate IX, 28. The Twenty Ounce and pippin apples are, by the nature of their rapid development, the most likely to attain the size necessary to withstand the feeding punctures of the bugs and thus to develop mature scars from this species. It appears certain that in western New York the work of *Heterocordylus malinus* in producing knotty fruit is very limited or entirely absent on the standard varieties of apples.

The colon apple leaf bug
(*Paracalocoris hawleyi pallidulus* McAtee)

One of the leaf bugs which was frequently found breeding on apple was *Paracalocoris hawleyi pallidulus,* a form that usually develops on the tender shoots about the roots and the trunk of the tree. When abundant it may move to the branches above and occasionally feed on the young fruit. A few such fruits were tagged, but no mature apples were obtained showing scars caused by this species.

The clouded apple leaf bug
(*Neurocolpus nubilus* Say)

Another leaf bug which has been reported as feeding on apple in Canada, and which the writer found breeding on apple in Genesee County, is *Neurocolpus nubilus* Say. This species also was found to prefer the tender shoots on the apple tree, and in this case the bugs were not observed feeding on the fruit.

The rosy apple aphid
(*Aphis sorbi* Kaltenbach)

The rosy aphid, when present on the apple tree, makes its presence known just as soon as the young fruits are set, and immediately develops so rapidly and in such numbers that the young fruit stems and adjoining leaves soon become pink with the crowded aphids. By the time the young fruits are one-half inch in diameter, or by the end of June, this species of aphid migrates from the apple tree, but not before it has done considerable damage. The rosy aphid prefers to develop on the lower limbs and on the inside or shady parts of the tree, but in years when it is abundant and the season is favorable it may spread to all parts of the tree and do immense damage unless control measures are taken by spraying at the right time. The writer found this aphid present each season in limited areas, particularly on Rhode Island *Greening* trees and in orchards where the trees were crowded and not properly pruned.

Where the rosy aphid has developed and has sapped the stems of the young apples, the fruits never become thinned out during the June drop. All infested fruits remain on the tree, forming clusters where there should be only one apple growing. A typical group of young fruits just recently abandoned by the rosy aphid is shown in Plate IX, 29. The cast-off skins of the developing aphids are shown on the leaves, and each fruit that set following the bloom still clings and continues to develop very slowly in its gnarled and injured form. This species of aphid does not remain long on the fruit, for by June 25 the winged forms were rapidly developing and leaving the apple tree in favor of their alternate, or summer, host plant. It appears that the feeding aphids have a tendency to harden the stems of the young fruit, causing each one so affected to cling and produce the crowded and undersized condition of fruits so characteristic of trees where aphids have been at work. Few if any seeds are present in the apples thus affected, and all retain a gnarled and malformed shape, particularly a puckered appearance at the base and at the calyx end (Plate XI, 32). In Plate X, 30, is shown a cluster of six young apples, photographed on the tree on July 4, which were identical in appearance on June 24 to those in the cluster shown in Plate IX, 29. The same six fruits (Plate X, 30) are shown in their natural size at picking time (September 25) in Plate X, 31. The fruits still show the heavy coating of spray material to which the tree was subjected during the first week in August.

All varieties of apples are infested in years when the season is favorable to the increase of aphids, but of the standard varieties the Rhode Island *Greening* and the Baldwin apples are the most frequently affected. It was observed that Baldwin apples may be infested only very slightly by the

aphid, yet each apple will remain on the tree until picking time, being about one-third the normal size for that variety and showing the characteristic puckering effect at the calyx end. Systematic thinning of the young fruits helps somewhat to increase the size of apples thus affected, but still the result is far from satisfactory to the grower. The most distinctive malformation caused to the apple by the rosy aphid is the puckering at the calyx end, which is very often accompanied by puckering at the base also. In Plate XI, 32, are shown three pippin apples (September 9) which were puckered chiefly at the base, this probably being due to the fact that in this variety the young apples developed and increased in size so rapidly that the aphids did not work beyond the broad base as they do on the small fruits. Heavily infested fruits usually develop a characteristic ribbing and warting of the surface, a condition produced only by clusters of these small insects. The uneven surface and puckering of the fruit is due to the fact that where the cells are punctured by the sucking aphids, little growth takes place, while the surface between punctures tends to grow; hence the warting. Red Astrachan apples affected by the rosy aphid are stunted similarly to other varieties, and in addition they are found to ripen sooner than other fruits on the tree. A fruit cluster of this variety which was infested by aphids in June was found to be ripe and cracking open by July 13.

On May 28, 1915, a killing frost occurred in western New York, destroying all the fruit in many of the orchards. A curious phenomenon was noted in those orchards where the fruit was killed, namely, that the fruit clusters infested by the rosy aphid did not wither and fall as did all other fruits. The apples in the aphid-infested clusters were found to be without seeds and were very much stunted and malformed. These aphid-infested and frosted fruit clusters were found to cling to the tree throughout the summer and even until picking time.

The apple leaf aphid
(*Aphis pomi* De Geer)

The apple leaf aphid breeds on the tree throughout the season but becomes most abundant during July, the period immediately following the disappearance of the rosy aphid from the apple tree. The injuries it produces are usually made in a slightly different manner from those of the rosy aphid. *Aphis pomi* is always most abundant on the new succulent growth, and particularly on young trees that are growing rapidly. In years when the season is favorable for aphid development, even the large and well-pruned trees of standard varieties become seriously affected. The damage caused by this species is often not so much in stunting or

malforming the fruit as in the production in vast quantities of honeydew which covers the fruit. A black fungus soon develops on this honeydew excretion, covering the leaves and the fruit to such an extent that the latter is rendered unsalable from its appearance alone (Plate XI, 34). This aphid usually works only on the fruit stems and the leaves, checking the growth of the apples to such an extent that by picking time they are only half or one-third the size of normal fruit. But in years of greatest abundance the aphids may even cover the whole apple and produce the puckered fruit so characteristic of the work of *Aphis sorbi*. The fruit is usually an inch or more in diameter by the time the leaf aphids begin to cover the tree. By that time the June drop has caused a thinning of the fruit, and the apples that remain during July are expected to develop and reach maturity.

Because of its later development, this species does not normally produce the clustering of fruits to such an extent as is found in the case of *A. sorbi*. In Plate XI, 33, is shown a cluster of Baldwin apples which were infested by the rosy aphid until June 25 and then by *A. pomi*, which followed immediately and persisted until July 20. The puckering of the fruit was caused almost entirely by the rosy aphid, while the black and smutty appearance produced by honeydew and fungus is the natural result always following in the wake of *A. pomi*. Very frequently young and thrifty apple trees may produce fruit of normal size, yet the aphids developing almost exclusively on the leaves will excrete sufficient honeydew to cover the apples and make them unsalable from their appearance. One can invariably detect the work or the previous infestation of *A. pomi* from the fruits alone, since the black or smutty appearance caused by the fungus remains for a long time.

The San José scale

(*Aspidiotus perniciosus* Comstock)

At least four species of scale insects may occur on the apple in New York, but the one most frequently seen on the fruit is the San José, or pernicious, scale. If this scale is at all present on the tree, it is almost sure to make its appearance on the fruit before the apples reach maturity. One scale-infested orchard that the writer observed was always treated with the dormant lime-sulfur spray, but apparently there were always a few spots left untouched by the solution since the insects invariably developed on several trees and a certain percentage of the fruit always showed the scale spots. In the fruits observed and photographed, the young insects began settling on the apples during July. They were few in number at this time, but before the fruit was picked these first scales had matured

and had produced numerous young which covered the stem and calyx ends, and frequently the sides of the apple as well (Plate XII, 35 and 36). The lenticels in the skin of the apple show as minute white dots, while the young scales may invariably be distinguished by the appearance of a still smaller dark speck in the centers of the spots formed by them.

On badly infested trees the stem and calyx ends of the apples are usually found to be plastered with numerous small black scales which cover the half-grown insects and form a grayish, roughened, scurfy mass on the skin of the fruit (Plate XII, 35). The largest scales, covering the full-grown females, are nearly circular in outline, grayish in color, and about the size of a pinhead; while the smaller, half-grown scales are blackish, with a central gray dot surrounded by a black depressed ring which in turn is surrounded by a grayish ring. One can usually distinguish the San José scale from other closely related species by the form of the young scale, the raised cone point at the center of the scale, and the surrounding black depressed ring.

When infested apples mature on the tree, a red color develops around each scale or cluster of scales which gives a very characteristic and well-known scale-infested appearance to the fruit (Plate XII, 36). In a favorable season, such as 1914, when rains occur during August and produce a late scab-infection period, some of the early-maturing apples, particularly Maiden Blush, may develop a color about the tiny scab infections, producing an effect not greatly different from that of scale (Plate XII, 37). In the writer's experience a good many growers have noted this late scab infection with considerable concern, thinking it must be the San José scale. A person familiar with scale could scarcely make this mistake, however, since a close examination shows the absence of any scale and in its stead a tiny black spot surrounded by a pale, scurfy-like ring caused by the scab fungus forcing up the thin, transparent layers of epidermis, beyond which color may develop in the skin of the fruit. Late scab infection is shown in Plate XLII, 181, on a Rhode Island *Greening*, which is typical of the dark green varieties in that no color developed about the points of scab infection.

The oyster-shell scale

(*Lepidosaphes ulmi* Linnaeus)

Another scale which is frequently found on apple trees throughout New York State but is not of prime importance is the oyster-shell scale. This species may infest trees to such an extent that limbs may be killed, but since it has only one brood in New York there is scarcely any opportunity for the young to settle on the fruit. The tiny young scales are hatched

and complete their active period of moving over the tree before the apples set, and therefore in the northern localities there is little opportunity for infesting the fruit. Apples showing the oyster-shell scale developed on the fruit are on record, but these fruits evidently all came from more southern localities where two broods of this scale develop in one growing season.

The scurfy scale

(*Chionaspis furfura* Fitch)

The scurfy scale is recorded from several localities in New York, but the writer failed to find it infesting the apple in the western part of the State. Slingerland and Crosby record two broods of this scale at Ithaca, New York, and the writer has seen the scales on the fruit of pear from the same locality, which would indicate that two broods had developed. In localities where two generations develop, the second brood might be expected to produce some scale on the fruit in those orchards where it occurs on apple trees. This species of scale is easily distinguished by the broad, grayish white, pear-shaped female scales, with two minute cast skins clinging to the smaller end of the broad, thin, whitish part which forms the scale proper.

LEPIDOPTERA

In the Lepidoptera only the immature, or larval, stage of the insect is able to do damage to fruit. The adults have sucking mouth parts suited for taking up nectar or other substances in liquid form, and thus they rarely have opportunity to injure fruit. Ripe peaches are sometimes ruined in the Central States by depredations of the migrating cotton moths (*Alabama argillacea*), which sometimes congregate in large numbers to sip the sweet juice of ripened peaches. The writer has seen army-worm moths (*Cirphis unipuncta*) feed on the juices of very ripe Bough apples on the tree. But aside from such rare occurrences, it may be stated that the adult insects of this order do not cause injury to fruit. The lepidopterous larva is provided with mandibles by means of which it cuts and prepares its food for entry into the alimentary tract; therefore, although the adult is a sucking insect, the larval stage must be placed in a group commonly designated, for convenience, as having biting or chewing mouth parts.

Lepidopterous larvae may feed externally or internally on the apple. As representatives of internal feeders, the codling moth and the lesser apple worm furnish the most conspicuous examples. The internal feeding results in wounds that never heal perfectly, usually ending in brown rot, premature ripening, and falling of the fruit before picking time. Wounds

made by the external feeders — and these species are the most numerous — will often heal over, producing a characteristic scar, provided the injury occurs prior to mid-July while the apple is growing rapidly. Wounds produced later than the middle of July will invariably result in brown rot, for with the slowing-down in growth the healing powers of the fruit are not sufficient to overcome infections. Furthermore, the extent to which the fruit may be injured and still recover depends much on the number of apples on the tree, as well as on the rate of growth at the time of injury. These factors are dwelt upon more at length elsewhere in this paper.

The codling moth

(*Carpocapsa pomonella* Linnaeus)

The codling moth is the oldest, the most destructive, and probably the best-known pest on the fruit of the apple. The moderately large, pink-tinted larvae are only too frequently found boring through the flesh of the fruit and forcing out the brown frass from the exit of their burrows — a sight familiar to all who frequent orchards or eat newly ripened apples. There are, however, certain phases of codling-moth work which are not always recognized by the casual observer, and it is these obscure features that the writer has sought to present and illustrate herein.

As an aid to the understanding of injuries produced by the codling moth, a review of the life history for a typical growing season is presented as observed in western New York during 1914. The spring brood of moths began emerging on June 3, and came forth in greatest numbers between June 8 and June 14, or for a period of a week immediately following the closing of the calyx on the young apples. The eggs were probably laid in greatest numbers between June 10 and June 20, and the newly hatched larvae began entering the fruit about June 10 and were entering in maximum numbers up to the end of the month. From July 1 on, the larvae entered the fruit in gradually decreasing numbers through the period up to July 25. The last moth to emerge in the cages, from the larvae kept over winter, came forth on July 15, and in the orchard this moth might have been expected to lay eggs as late as July 25.

The first larva of the spring brood which was observed to have completed its growth did so by July 6, and others were found to be leaving the fruit on July 8 (Plate XII, 38). Several trees in an unsprayed orchard were stripped of the rough bark and then kept continuously banded with burlap. In this way most of the larvae that completed their growth and sought suitable places under the bark for spinning cocoons were always found in the burlap. Several such larvae were taken from the bands on July 11. These larvae spun cocoons immediately on enter-

ing the burlap bands, pupated within three days, and after a rest period of ten days began emerging as moths of the second brood. In the cages the first moth of the second brood came forth on July 24, but the majority of those that emerged appeared between July 28 and August 10. From these data it is apparent that the egg-laying period of the first-brood moths extends up to and may slightly overlap the appearance of the second-brood moths.

Larvae that had been collecting since August 3 were taken from the bands on August 8, and from this lot one or more moths emerged each day between August 15 and August 27. The larvae that entered the bands on the trees after August 8 did not transform, but remained in the larval stage until the following spring. The larvae produced by the late-emerging second-brood moths were always abundant in the unsprayed orchards during September, and a few were to be found attacking the fruit practically up to picking time. The line of demarcation between the two broods of larvae is not apparent from the work on the trees, since the work of the late first-brood larvae is similar to that of the "side-worm" injuries produced by the second brood. During the last ten days of July it was always possible to find a few tiny larvae just entering the fruit, and these could not be assigned with certainty to either brood. The last larva that the writer could assign definitely to the belated first-brood moths was found entering an injured Baldwin apple on July 20 (Plate XIV, 46), working its way in at the bottom of a scar produced by the fruit-tree leaf roller. Thus it is seen that the two broods of moths overlap in their period of activity and there is a time during which larvae from both broods are to be found entering the fruit.

From these observations and similar ones made during 1913, 1915, and 1916, it may be stated that in western New York the codling moth produces one full brood and a partial second brood, the size of the latter depending apparently on the character of the season. The method of attack by first-brood larvae is fairly well known, in that the majority of the young larvae enter the fruit by way of the calyx end. It is the habit of the larva to always seek some depression on the surface of the fruit; when the apple is small it is usually the calyx cup, but later, when the apple is large, the point of entry may be at any break or scar in the fruit skin or at a spot where a leaf rests closely against the apple. After feeding for a short time in the calyx cavity, which is its usual procedure in June, the young larva works its way to the center of the fruit, where it devours some of the seeds and the core tissue. After the fruit has attained considerable size, the newly hatched larva is as likely to enter on the side or the stem end as to find its way to the calyx cup. It rarely enters, however, on the smooth exposed surface of the apple, preferring

to work in at some slight depression, at a contact point between two apples, or where a leaf gives some protection from the sun. When nearly grown the larva invariably works its way to the surface of the fruit and begins forcing excrement from the burrow (Plate XIV, 43), and this frass, taken with the premature ripening of the fruit, is a certain indication that the codling-moth larva is at work. The exit hole is kept carefully closed with frass, probably as a protective measure against parasites and predacious enemies. But when growth is completed, the larva departs from the fruit, forcing out the frass plug. An open burrow is a sure indication that the larva has deserted the fruit and gone in search of a suitable place in which to spin a cocoon.

By the end of June and during the first week of July, when the apples are about one inch in diameter, the larger and more advanced of the first-brood larvae begin forcing out the characteristic brown frass from their burrows. The apple shown in section in Plate XII, 38, illustrates this very well, the larva being fully grown and practically ready to leave the fruit. The exit to the burrow is most frequently in close contact with a leaf or at a point where two apples rest in contact (Plate XIII, 40), and such a condition probably lends some protection to the larva against its parasitic enemies. The extent to which the codling-moth larva may burrow in the small fruits is shown in Plate XII, 38, photographed on July 8. Such apples invariably drop within a few days, but the larva leaves the fruit first unless a storm or an unusual wind intervenes. During the latter part of July, when the apples are much larger, the feeding larva gradually works its way to the core of the fruit, where it feeds on the seeds and the surrounding pulp. In Plate XII, 39, is illustrated the kind of cavity that the larva makes in a large apple. The two apples shown in Plate XIII, 40 (photographed on July 28) present the characteristic appearance that results when two or more larvae begin work where two apples rest in contact. The apples were spread apart for the photograph and the work of more than one larva may be detected. Probably three or four larvae started work between the two apples, and the two that survived until the photograph was taken had been at work perhaps not more than ten days.

The codling-moth larvae that enter the apple during the latter part of July and in August and September, most frequently enter at some scar, at some abrasion of the skin where two apples touch one against the other, or under a leaf that lies in close contact with the fruit. A high proportion of the larvae evidently do not succeed in entering far into the apple, but die from various causes soon after making a small opening through the skin of the fruit. The tiny newly hatched larvae probably seek the shaded and protected parts of the fruit for definite reasons. In fact, few

if any larvae ever succeed in entering on the side of the apple where the hot sunshine beats upon it. It is apparent that the young larvae are not able to withstand the excessive amount of sap that issues from a fresh wound. This is particularly noticeable if the sun shines hotly upon the fruit, for many larvae are found dead apparently from the effects of the hot sap that boils out. If the larva is successful in its efforts to enter the fruit, a white frothy spot covers the point of injury (Plate XIII, 41). This frothy spot gradually dries up and turns to white powder, soon to be followed by brown excretions from the larva. The larva remains near the surface for five or six days, gaining slightly in size and strength in order that it may be able to withstand the sap pressure which it must resist while working its way to the core. Having arrived at the core, the larva finds air space about the seeds and plenty of food; thereafter its chances of attaining maturity are very good.

On one occasion (September 12) a large apple was cut in section, and in the seed cavity was found a small white larva about one-third grown. A slender burrow indicated that the larva had worked its way in from the stem end of the apple. This particular larva was unusually white, with the head and the cervical shield black — effects possibly produced by an exclusive diet on seeds. The larva was so unusual in color that it was reared, in order to make sure that no other species was involved.

In Plate XIII, 41, is shown a pippin apple on which eleven young codling-moth larvae had tried to enter on the side of the fruit that was shaded by leaves. The tree had been sprayed on August 6, and apparently some of the larvae had died from the effects of the poison, for only five of them were found to be alive. The young larva will usually feed for two or three days at the surface, and because of this habit many larvae get spray poison but not before the skin of the fruit is punctured and a pinhole injury is produced. Large numbers of perfectly shaped apples must be discarded in the grading process due to the small pinhole injuries that result from the efforts of young larvae to enter the fruit, and, even though the larvae die in the attempt, the injury is not prevented (Plates XIII, 42, and XIV, 47). Slices with pinhole injuries, taken from apples that were sprayed for second-brood larvae, are shown in the latter figure. In case the larva was not killed, a white exudation persisted about the point of injury (Plate XIV, 47, a); while in case the larva died, the spot turned brown and dried up. The white deposit probably resulted from the evaporation of the excess fruit juice liberated by the young larva, rather than from any product of excretion. During August and September the apples that are exposed to sunshine will invariably develop color around the pinhole injuries (Plate XIII, 42), much as they do around scale insects. The color serves to enlarge the spot and make it more con-

spicuous. All such spots, in fact all pinhole injuries, soon become much enlarged, due to the development of brown rot. At picking time all but the more recent pinhole injuries appear as brown, sunken spots having a tiny hole at the center (Plate XIV, 47). When undisturbed by rubbing, the smallest and most recent pinholes will show the characteristic white powdery substance about the opening (Plates XIII, 42, c, and XIV, 47, a).

Rarely, if ever, do two codling-moth larvae come to maturity in the same apple; when more than one larva is present in a fruit they fight for possession, the conqueror usually devouring the vanquished. The Rhode Island *Greening* illustrated in Plate XIV, 43 (photographed on September 26), shows excessive tunneling for one larva. It has four exits to the surface, one on each side with the plug removed as if two larvae had departed from the fruit. In Plate XIV, 44, the same apple is shown in section, with all the tunnels more or less connected at the core but not like the common runway of a single larva. Brown rot, which invariably develops in the larval tunnels, is clearly shown surrounding the right-hand tunnel.

Various species of flies, particularly *Pollenia rudis* and several large species of muscids, are frequently found feeding and enlarging holes that were started by the young second-brood codling-moth larvae (Plate XIV, 45). The flies sip up the juices found in the brown-rot spots and thus enlarge the primary injury into a deep, rounded hole, in many cases cleaning out the brown rot down to the living tissue.

The lesser apple worm

(*Enarmonia prunivora* Walsh)

The lesser apple worm has frequently been confused with the codling moth, and is in fact closely related to that species but is much less abundant in New York. The full-grown larva is very similar to that of the codling moth, but is smaller and on close examination can be distinguished by the comblike structure on the caudal curvature of the anal plate. The work of the lesser apple worm during August and September can readily be distinguished from that of the codling moth by the nature of its burrows. In its early stages, at least, the larva remains near the surface of the fruit, eating out a blotched mine consisting of numerous tunnels just beneath the skin of the fruit (Plate XIV, 48). When half grown it may eat its way to the core, as shown in the section at the left of the figure. This section, taken from just beneath the typical surface mines, shows that the larva had made at least four tunnels to the core. The larvae of this species continue working on the apples until picking time, and any undetected larvae that have a start on the fruit may con-

tinue work even after the fruit has been placed in barrels. The work of the lesser apple worm is the most likely to be confused with that of the red-banded leaf roller (*Eulia velutinana*), described later; but in the case of the latter species, the skin of the fruit is eaten as well as the flesh underneath.

The fruit-tree leaf roller

(*Archips argyrospila* Walker)

The larvae of the fruit-tree leaf roller, when numerous on apple trees, may be very destructive to the fruit. The eggs of this species hatch at about the time when the fruit buds are swelling and separating slightly at the tips. The tiny larvae immediately bore into the fruit buds and begin their destructive work by destroying fruit clusters before the fruit is set. By the time the tree is in full bloom, the larvae have begun to spin silken threads, drawing together the blossom cluster with the new leaves into a loosely woven nest within which they feed. By the time the petals are falling, one larva will have destroyed a single fruit cluster; and as soon as the young apples begin to form, it will move to a new cluster, there to begin devouring the newly formed fruit (Plate XV, 49). As the apples grow larger, cavities are eaten into them by the larva, which remains close at hand in a rolled and webbed leaf that serves as a retreat (Plate XV, 50). One may frequently see a larva reaching out from its retreat and feeding at the base of an apple. This is a characteristic habit of the larvae after the apples have attained one-half inch or more in diameter. Usually the open end of the retreat is in close contact with the fruit, and so the feeding operations cannot be easily observed.

During the last ten days of June, after the apples have attained from one-half to three-fourths inch in diameter, the majority of the fruit-tree leaf-roller larvae complete their growth and change to pupae. Nearly all of the fruits injured by the larvae prior to June 20 drop as a result of the injury. Many of the apples fed upon after that date also drop, but the number of these is largely dependent on the abundance of fruit on the tree. As in the case of injuries by the apple redbugs, it is the weakest or the injured fruits that drop first; when there is a heavy set of fruit, the larvae may actually help thin the fruit, but when the set is light, many of the injured fruits will recover and grow to maturity, showing an ugly scar. The growing season of 1914 was normal and the set of fruit was heavy, and as a result the majority of injured fruits did not survive the June drop. An estimate for 1914, determined by counting the fruits tagged and by constant observation of the fruit injured after the apples had set, would place 95 per cent of the injured apples as dropping, and 5 per cent as recovering and growing to maturity showing a scar. In

orchards that were badly infested by the fruit-tree leaf roller, at least 10 per cent of all the apples that remained on the trees showed scars caused by this insect. Apples that grew to maturity showing a scar were those injured by late feeding of the larvae, for the most part after June 20. The tag experiments showed that all fruits injured prior to June 18 dropped, and only a few of those injured on June 18 and 19, which had the advantage of having all near-by fruits pruned away, were able to survive. The typical deep injuries made by the larvae after June 20 are shown in Plate XV, 51 and 52. These apples were picked and photographed on June 24. They would have recovered and grown to maturity showing typical scars, as did others similarly injured.

During early July, the apples that remain after being injured by the feeding larvae rapidly form a new surface over the wound; at first a brown, corky layer of dead cells covers the wound, but this soon cracks and falls away following the formation of new skin beneath. The mature scar has a bronze color and a slightly roughened surface. The character of the scar, as well as the ability to recover from the wound, varies according to the variety of apple affected. The power of recovery from wounds is particularly noticeable in the pippin and Twenty Ounce apples. Those apples that gain in size very rapidly may recover and grow to maturity even though the seeds have been eaten out. In Plate XV, 53, are shown three pippin apples, at picking time, which had been fed upon and had part of the core removed and yet grew to maturity. This may happen occasionally with a Rhode Island *Greening* or a Baldwin apple, but is rather unusual with these varieties. Typical leaf-roller work on Baldwin apples may be seen in Plate XVI, 57. In Plate XV, 54, is shown injury to Twenty Ounce apples (photographed on July 8) in which the feeding larvae reached the core on June 20; the smallest apple was ready to drop, but the others were recovering and would have attained maturity. On pippin and Twenty Ounce apples one may find unusually large scars made by the leaf-roller larva. Since these varieties grow very rapidly, the small feeding cavities made by the leaf roller will be expanded with the growth of the fruit until the scars are comparable in size to the work of green fruit worms on Baldwin and Northern Spy apples.

Very few leaf-roller larvae are to be found at work later than July 1, but the few that do work late produce some unusual scars which may prove difficult to identify. The scars that result from the work of larvae feeding as late as June 30 are unusually small and shallow. Such scars may sometimes be very similar to the shallow wounds produced by green fruit worms (*Xylina* spp.). However, the work of the fruit-tree leaf-roller larva can usually be recognized by the fact that some part of the scar will show a deep or a narrow excavation. Comparison between the

work of leaf-roller larvae and the work of fruit worms is shown in Plate XVI, 55 and 56, photographed nearly two weeks after the injury occurred. The broad, shallow work of the fruit worms is readily distinguished from the deeply excavated or narrow channels produced by the leaf-roller larvae. The work of the leaf roller shown in Plate XVI, 55, was selected as a sample of some shallow excavations, which is not the usual or typical work of the species and yet can be recognized as different from the broad, shallow work of fruit worms. Unusual types of scars caused by the leaf roller are shown in Plate XVI, 58 and 59. In rare cases the larva may move to a new apple only two or three days before it is ready to pupate, or it may be forced to abandon an apple prematurely, and in such cases typical scars would not result (Plate XVI, 59). The deep excavation in the Twenty Ounce apple shown in Plate XVI, 58, has been filled out by growth and to some extent produced a warted surface. Scars of all types may show accelerated growth if the conditions are right to force growth late in the summer, after the skin of the fruit has hardened.

The work of aphids on the fruit always has a tendency to stunt growth and harden the stems in such a way that injured or weak fruits are made to cling for a much longer time than they otherwise would. In one case observed, two apples were severely injured by a leaf-roller larva about June 15, but the apples were made to cling until July 8 (when they were picked), due to an infestation by the rosy aphid, which developed on the fruit cluster about the time when the injury was produced.

The problem of determining scars may frequently be made difficult by the work of two or more species occurring on one fruit. But after sufficient experience in observing typical scars for each species concerned, one may hope to determine accurately 98 per cent of all the scars found.

The oblique-banded leaf roller

(*Archips rosaccana* Harris)

The oblique-banded leaf roller occurs along with *Archips argyrospila* in the orchards of western New York, but is not nearly so abundant. In certain orchards one-tenth of all the leaf-roller larvae examined were found to be this species. The work of *Archips rosaccana* on the fruit does not appear to differ from that of *A. argyrospila*. In the field, while the larvae are actively at work, one may distinguish *A. rosaccana* by its yellowish brown to pale apple-green color and its brownish black head and thoracic shield, as contrasted with the invariably black thoracic shield and apple-green color of *A. argyrospila*. When determining the mature scars on apples as the work of leaf-roller larvae (*Archips* spp.), one is bound to include some work produced by *A. rosaccana* but the percentage will

be small. A second brood of the *A. rosaceana* larvae appears on the tender foliage of the trees in July and August, but were not found by the writer to infest the fruit.

The green fruit worm
(*Xylina antennata* Walker)

In western New York the commonest species of green fruit worm attacking the apple is *Xylina antennata.* The over-wintering moths come forth to lay eggs on the apple twigs before the buds have turned green. The eggs hatch during the first warm days, and the tiny larvae begin feeding on the tender leaves as soon as the buds begin unfolding. By the time the fruit is formed, the larvae are half grown, and, having a voracious appetite, are capable of devouring the young apples rapidly. The larva of this species is usually distinguished by the green color, the broad white lateral line, and the numerous small pale spots on the laterodorsal surface. In 1914, which may be considered as a normal season, some of the larvae had completed their growth by June 15, or before the apples were one-half inch in diameter; others were more retarded in their development and did not finish feeding before June 20, and a few even later. The larvae that fed on the fruit on June 18 and later, were the ones producing the scars that showed on the apples at picking time.

The fruit worm is large when the apples set, and consequently the effect of its feeding is to cause the fruit to drop. When the apples are small, many of them are completely eaten. Only after they are one-half inch in diameter, and when growth is rapid, are they able to recover. A comparison is shown in Plate XVII, 60, between a fresh half-eaten apple injured by the green fruit worm, and an apple showing the deeply excavated and smaller scar produced by the larva of the fruit-tree leaf roller. This difference in scars is nearly always apparent, particularly in freshly injured apples, in which the broad, coarse, mandible marks of the fruit worm may be distinguished. A nearly full-grown larva of *Xylina antennata* is shown in Plate XVII, 61, excavating a deep, narrow wound to the core of an apple, but this manner of feeding is unusual. In a few cases a fruit-worm larva was found entirely inside an apple, having eaten out the core and enough of the pulp to form a retreat within. As a rule the larvae are intermittent and restless in their habits, feeding on one apple for a short time and then moving to another. This habit makes the fruit worm much more destructive than it would be otherwise, for the apples that are only slightly injured are likely to recover and grow to maturity showing a scar. The small scars made by a larva about June 10, when it was only about one-third grown, are shown in Plate XVII, 64. The

injury was so slight that the apples were recovering and the scars had healed over by June 24, when the photograph was made. One larva often feeds on a dozen or more fruits, or on all the apples on one small limb. The way in which one larva may feed on several fruits is well illustrated in Plate XVII, 65, showing how several pears on one limb were fed upon by a single larva but all recovered and bore ugly scars.

The broad scars produced by fruit worms on or before June 18 are usually so severe that the apples rarely recover, and yet in a few cases, where the set of fruit is light and growth is forced by warm rains, the fruits may grow to maturity. Scars made on June 20 are shown in Plate XVII, 62, as they appeared on June 24; the scars have turned brown, which is the first stage in the healing process. In Plate XVII, 63, are shown two apples that were injured on June 18; on June 24, when the photograph was made, the scars were rapidly healing, as is indicated by a few cracks in the brown corky layer composed of cells that died from the injury. A Rhode Island *Greening* apple which was injured on June 18 by the intermittent feeding of a green fruit worm is shown in Plate XVIII, 66, as it appeared on August 14. The broad, shallow scars are characteristic of fruit-worm injury but may sometimes be confused with the work of the white-marked tussock moth, discussed later. In one experiment a green fruit-worm larva was observed to feed on six apples from June 18 to June 20 inclusive, and during this time each apple received one or more feeding scars. This experiment was typical of the intermittent feeding in which several apples are only slightly injured, the scars being shallow and not very broad.

A comparative study of the scars made by green fruit worms on different varieties of apples shows some of the same differences developing that were noted in studies of the fruit-tree leaf roller and the apple redbugs. Twenty Ounce apples and pippin varieties were found to recover when severely injured, in many cases even after the core had been partly eaten. A most unusual recovery after injury by a green fruit worm was shown by a pippin apple (Plate XVIII, 67) in which the core and half of one side were eaten away, and in addition the larva devoured a part of the opposite side. The same apple if turned slightly would show how the scar extends to the center of the core, the new tissue folding inward over the cavity during subsequent growth. An unusual recovery for a Baldwin apple is shown in Plate XVIII, 68; a fruit worm ate part of the core on June 25, but the apple recovered and grew to maturity. For fruit-worm work this scar is rather small and deep, and might be confused with certain scars produced by the fruit-tree leaf roller.

The usual kind of scars produced by the green fruit worm and found on the fruit at picking time, is shown in Plate XVIII, 69 and 70; scars

appearing in the form of large wounds, more or less shallow, perfectly healed, bronze in color, and usually with bits of dried corklike tissue still clinging in places. Apples so injured keep perfectly in storage, but the disfiguration is taken as sufficient reason for discarding them in the grading process. Baldwin apples with typical scars are shown in Plate XVIII, 70. A scar on a Tompkins King apple which in outline is somewhat suggestive of the injury produced by the white-marked tussock moth, is shown in Plate XVIII, 69; but the old and dried-out corky tissue clinging to the scar indicates a period of healing prior to the time when the tussock-moth larvae begin their work.

The green fruit worm

(*Xylina laticinerea* Grote)

Another green fruit worm, which is second in abundance in western New York, is *Xylina laticinerea*. The larva of this species is distinguished from *X. antennata* by having a more slender white lateral line, and a median dorsal line equally distinct. The habits of both species are very similar and no distinction can be drawn between the injuries they produce. A larva of *X. laticinerea,* nearly full-grown, is shown in Plate XIX, 71, with four young apples on which it was feeding on June 18. The broad, rough scars produced by fruit worms are well shown in this photograph.

The red fruit worm

(*Rhynchagrotis placida* Grote)

A species conspicuous because of the red color of the larva, and occasionally found feeding on the apple in western New York, is *Rhynchagrotis placida* Grote. The larval habits of this species are slightly different from those of *Xylina* spp. *Rhynchagrotis placida* has been classed as a climbing cutworm, and such larvae are supposed to climb up the trees only at night for feeding. The writer occasionally found larvae of this species resting during the day, if not feeding, within the cavities they had eaten into the apple. When disturbed they curl up, as is the habit of certain cutworms, and in this respect they differ from species of Xylina. The larvae of *R. placida* are rather sluggish and do not move from one apple to another as freely as do the green fruit worms. Because of this habit, the apple fed upon usually shows two or three irregular scars. A Rhode Island *Greening* apple which was fed upon by one larva from June 16 to June 19 is shown in Plate XIX, 72; the photograph was made on August 16, and shows several irregular scars that resulted from the work of the larva. A Baldwin apple with a large, irregular scar is shown at maturity in Plate

XIX, 73. In each case the scars are large and very irregular, deep in some places and shallow in other parts — characters that may often enable one to recognize the work of this species. The age of the healed surface, being similar to that in the case of injuries produced by green fruit worms, will serve to distinguish the scars from those made by the tussock moth at a later date.

The white-marked tussock moth

(*Hemerocampa leucostigma* Smith and Abbot)

The white-marked tussock moth was found very abundant in a few apple orchards in Genesee County, New York, and became very destructive to the fruit. The egg masses, which remain on the trunk or the large limbs of the trees all winter, do not hatch until after the trees bloom and the fruit has set. The young larvae are not large enough to attract attention or feed on the fruit until about June 20, but, having started, they keep up their destructive feeding until after the June drop occurs, some larvae feeding as late as July 12. Consequently the injuries they produce are more likely to be in evidence as scars on the mature apples, since the fruits in most cases are large and are able to withstand the shallow feeding which occurs after June 25.

The larvae of the tussock moth normally feed on the tender foliage of several varieties of trees, but when they occur on apple trees they show a decided preference for the young, green apples. In observations on the feeding habits of the larvae it was noted that the early feeding (June 22) had a fatal effect on certain of the injured apples. The injured fruits were given such a setback in the struggle for sap and existence that the uninjured members of the fruit cluster outstripped the injured, with the result that many succumbed in the June drop which followed. Two larvae scarcely half-grown, feeding on the fruit on June 24, are shown in Plate XIX, 74. The larvae are restless in their habits, feeding for a short time in one spot and then moving to a new place. This habit, combined with shallow feeding, produces several scars on the same apple — a condition that enables one to recognize a high proportion of the scars produced by this pest. Two young Baldwin apples, photographed on July 4 (Plate XX, 76), show characteristic scars produced by the intermittent feeding of the half-grown larvae. As the apples get larger, one larva often remains feeding on the same fruit for five or six days (Plate XX, 75). The first scars produced begin healing while the larva still feeds on other parts of the same fruit. Some larvae may continue feeding on the fruit as late as the middle of July, but after the apples have grown larger and the skin has become tough the larvae are more likely to move to the tender new leaves to complete their growth.

After the middle of July the apples grow more slowly, and, as a result, injuries produced later than July 12 heal but very slowly and imperfectly. In fact, some of the tussock-moth larvae feed on the fruit until it is unable to replace the injury with new skin. Two Northern Spy apples photographed on July 20 (Plate XX, 79) show the long, shallow channels which the larvae make after the skin has hardened and is no longer tender to their liking. These fruits were injured between July 12 and July 15, the injured part drying out and shriveling slightly — the first indication of improper healing. A Rhode Island *Greening* apple photographed at picking time is shown in Plate XXI, 81; the scar is rough and hard, not having the smooth skin beneath as is found on scars that heal while the fruit is growing rapidly. Excessive late feeding by the tussock moth on a Rhode Island *Greening,* is shown in Plate XXI, 82, the injuries having been made so late that brown rot would have developed had the apple been an early-maturing variety. A Twenty Ounce apple which was fed upon by a tussock-moth larva after the middle of July (Plate XX, 80) shows how brown rot may start in any wound that occurs after the fruit has stopped active growth.

The mature scars produced on apples by the tussock moth may present curious shapes and forms. The scars may be recognized, however, by the following combination of characters: (1) scars always shallow, frequently imperfectly healed; (2) scars irregular in outline, exhibiting slender feeding tracts; (3) several small, perfectly healed, irregular scars on one apple, or one or more large, rough scars having narrow, irregular tracts at some points on the margin. The work of the larva during the last week in June is characterized by intermittent feeding, the larva starting a new feeding place at any point where it may happen to be when hungry. Such scars heal with a smooth surface, since the apple is growing rapidly. Later, when the skin of the apple has begun to get tough, the larva does not like to make a new puncture, but wanders around until it finds the previous point of feeding, there to enlarge the wound or to extend it in narrow channels as it feeds. On one Rhode Island *Greening* apple observed, ten small surface scars were counted, all made by one tussock-moth larva; some of the scars were so small that they strongly suggested the work of the pistol case-bearer. Three larger and more irregular scars are shown in Plate XX, 77. A large, sinuate scar, typical of the tussock-moth work, is shown on a Rhode Island *Greening* apple in Plate XX, 78. This injury was produced near the end of the period when perfect healing would take place, and consequently the skin of the apple was then becoming so tough that the larva preferred to feed by enlarging one spot rather than making new ones.

Warting of scars was found to take place on tussock-moth injuries, as noted in the case of other scars, whenever the conditions were right to produce such effects. A large mature scar on a Jonathan apple is shown in Plate XXI, 83, in which the scar tissue has bulged out above the general surface due to new and unusual growth just beneath the scar. Such warting is caused by accelerated growth after the skin of the apple has become hardened; the scar tissue, being formed later than the skin on the other part of the apple, gives way at the point of least resistance under the pressure caused by new growth. In Plate XXI, 84, a small scar caused by the tussock moth is shown in comparison with an old scab spot, which also shows the effect of warting under pressure by growth late in the season.

The palmer worm

(*Ypsolophus ligulellus* Hübner)

In some years the palmer worm is very destructive to apples, but thus far such years have been few and far between. The species is known to have been very destructive in New York in 1853, and not again until 1900. It is evidently always present in apple orchards but in very limited numbers. During the years from 1913 to 1916, inclusive, while the writer was constantly inspecting orchards in western New York, he found palmer worms in only a few orchards and usually as isolated specimens. The larvae were found in greatest numbers in two orchards which had suffered from neglect.

Although material for study was scarce, observations were made and photographs were obtained showing the character of the wounds produced by the palmer worm. No larvae were observed feeding on the fruit before the middle of June, but larvae found after that date were always working on the fruit. A typical example of the injuries produced during the latter part of June is shown in Plate XXI, 85, taken on June 25. The small, slender larvae, marked with pale longitudinal lines and with two broad dark stripes, move with a wriggling motion when disturbed, frequently abandoning the web-covered retreat on the fruit and dropping below on a silken thread. After feeding for three or four days on one apple, the larva invariably secretes itself under a web spun over the cavity which it has eaten into the fruit. Bits of web remain in the wound long after the injury is made (Plate XXII, 86), serving to identify the pest that did the damage. In Plate XXII, 88, is shown an apple, photographed on August 12, in which the larval web may still be seen in the scar.

All fruits injured before June 20 were found to drop, and only the late-scarred fruit, injured after that date, remained on the tree to develop

mature scars. The late work is characterized by deep and narrow scars (Plate XXII, 87). In certain cases in which the web spun by the larva is not visible, the work of this species might be confused with the late work produced by the fruit-tree leaf roller. In the case of a Roxbury apple photographed on July 21 (Plate XXII, 87), there are to be seen five small holes grouped closely together, the work of a larva during the last three days of June; but the bits of web found still clinging to the wound would serve to identify it as the work of a palmer worm.

The bud moth

(*Tmetocera ocellana* Schiffermüller)

The bud moth is well known as a pest chiefly because of the damage which the larvae may do by eating into the young fruit buds during May, thus destroying the crop before the fruit is formed. When abundant, this insect may also do considerable damage to the maturing fruit, and, for the present study, observations are recorded on this phase of the insect's activity.

The larvae that destroy the buds in spring, change to pupae during June. After ten days in the pupal stage, or during the last few days in June and the first two weeks of July, the moths come forth to lay their eggs on the leaves. In the latter part of July, the tiny, black-headed caterpillars hatch from the eggs and begin to feed on the under side of the apple leaves. All during September the small, reddish brown larvae may be found feeding on the under side of the leaves, usually hiding beneath a protective layer of web, this being constantly rebuilt to cover new feeding areas. When a leaf bearing a larva comes in contact with an apple, the leaf is frequently drawn against the fruit and firmly attached to it with web. Within this safe retreat the larva continues to devour parts of the leaf, and in addition it may eat several small round holes through the skin of the apple. The first work of this kind on fruit was found on August 8 (Plate XXII, 90), the larva having fed extensively on the leaf but having made only four or five holes through the skin of the fruit when disturbed. The same type of work is better shown on a Pound Sweet from which the leaf was turned back and photographed on September 15 (Plate XXII, 89). Even in well-sprayed orchards, many apples will be found that appear to be perfect and yet when they are picked a leaf is found sticking to one side, beneath which the work of the bud moth is revealed.

The work of bud-moth larvae on the maturing fruit may invariably be distinguished by a group of small holes eaten through the skin, while

the light area about the injury indicates that a leaf has been held in contact with the spot sufficiently long to make an appreciable difference in color. In case the injury has not been rubbed, bits of web and a white powder may be found about the scars. Although the wounds made in the fruit by the bud moth during September are small, when careful grading of the fruit is done or apples are selected for show purposes many perfectly shaped apples will need to be cast aside or relegated to the inferior classes due to these small feeding punctures.

The red-banded leaf roller

(*Eulia velutinana* Walker)

An insect that was doing a slight amount of damage to the fruit during August and September proved to be *Eulia velutinana* Walker, a species not ordinarily recognized as a pest on the apple. On July 28 the writer first noticed a larva of this species which was feeding in an unusual manner between two Genesee Flower apples (Plate XXIII, 91). This larva, with the apples, was placed in a breeding jar, where it pupated within a curled leaf on August 2. When full-grown the larva is very suggestive of *Archips argyrospila*, but is slightly smaller than that species. From the pupa developed on August 2, a moth emerged on August 11. The moth of this species has a tuft of hairlike scales on top of the thorax, is slightly smaller than that of *Archips argyrospila*, and has much less of the dark brown color. The spread moth is shown, somewhat enlarged, in Plate XXIII, 92.

The work of *Eulia velutinana* was frequently found on the fruit during August and September, and a few larvae were still at work when the fruit was picked. The larva is a surface feeder, evidently never eating deeply into the fruit as is done by the fruit-tree leaf roller. A typical example of the work found during August may be seen in Plate XXIII, 93. The larva prefers to live and feed on the fruit while secreting itself beneath a leaf or by working between two apples that rest in contact. Sometimes a detached leaf is fastened to the fruit with web, and this serves as a retreat or protection from which the larva can feed. Late in the season a decided preference is shown by the larvae for eating only the skin of the fruit (Plate XXIII, 94). A Baldwin apple which had been kept in a barrel for two months was found to have on November 29 fresh shallow scars, such as the late-feeding larva will produce, and attached to the fruit was some web in which the larva had secreted itself.

The work of *Eulia velutinana* during August and September may be distinguished by the broad and shallow feeding scars, which never heal

due to the lateness of the season. No other species was found to be doing a type of work that could be confused with the scars here illustrated. The damage to fruit caused by this species is doubtless done by larvae of a second brood, though the complete life cycle is not known.

The pistol case-bearer

(*Coleophora malivorella* Riley)

Case-bearers are interesting little insects, for the larvae of each species live within and carry about with them a case of a particular pattern composed of leaf fragments. The pistol case-bearer always constructs a case which in form resembles a pistol case. In western New York the pistol case-bearer was frequently found infesting apple trees, and particularly those orchards that had not received a thorough spraying just before the flower buds opened. The young larvae hibernate in tiny cases attached to the twigs of the tree, and as soon as the buds show green they move from winter quarters and cluster on the unfolding tender leaves.

As soon as the fruit sets, many of the larvae find their way to the young apples and begin feeding. The case-bearer larva feeds by making a round, deep hole through the skin of the fruit, and then mining out the parenchyma in all directions as far as it can reach without entirely deserting its case. Having obtained all the food possible at one point, the larva creeps along with its case to a new location, settles down, eats through the skin, and begins feeding as before. Pistol case-bearers, nearly mature, are shown in Plate XXIV, 95, at work on young apples on June 9; the small, round, black holes show points of previous feeding. One case-bearer may make several such feeding punctures on one or more apples.

The larval activity of a single case-bearer is well shown in Plate XXIV, 97. This larva began feeding on a Twenty Ounce apple, a variety that grows so rapidly and attains such size that the case-bearer is unable to kill the fruit. The regular progression in size of scars is due entirely to the effect of growth, the largest scars being those first produced while the smallest scars are those made by the larva's feeding after the apple had attained considerable size and when little expansion was possible by further growth. The clear spots in the leaf show the effect of larval feeding on the foliage. On completing its growth the case-bearer moved from the fruit to the adjoining leaf, and then to the twig, where a firm attachment was made preparatory to pupation. The moth emerged toward the end of June, but the case remained in position for a long time after. The photograph was made on August 30, after the apple had attained more than half its growth and was apparently stunted somewhat by the injuries received.

The mature scars frequently show a funnel-shaped depression at the center, indicating that the cavity produced by the larva is not always entirely filled out by growth (Plate XXIV, 96). This feature, combined with the numerous small, rounded scars on a single fruit, is characteristic of case-bearer work. The large scars that sometimes result from the very early feeding of the case-bearer larva might be mistaken for the rounded scars made by the tussock moth, were there not a gradation in size of the scars.

In a few instances the scars made by this case-bearer were found to produce a splitting of the skin about the wound, very similar to the way in which splitting and enlargement of the scar occur with redbug injuries. A good example of this is shown on a Detroit Red (Plate XXV, 98), in which the contrast between the bronze scar tissue and the red skin of the apple is conspicuous.

Several types of mature scars from Baldwin and Twenty Ounce apples are shown in Plate XXV, 100, slices from different apples being arranged in a group for purposes of comparison. The work of the case-bearer on a crab apple as illustrated in Plate XXV, 99, shows all types of scars and particularly the effect of warting. The skin of the crab apple hardens early in the summer while growth pressure is still being exerted; hence the more recent and tender scar tissue gives way to the new cell formation underneath.

The cigar case-bearer

(*Coleophora fletcherella* Fernald)

The second species of case-bearer frequently found in abundance in apple orchards is easily distinguished from the preceding species by the shape of the larval case. This insect has received the name *cigar case-bearer*. The life history of the species is very similar to that of the pistol case-bearer, and the injuries it produces cannot with any degree of certainty be distinguished from those of that species.

The cigar case-bearer, and its work on young apples just formed, are seen in Plate XXV, 101, an enlarged photograph showing well the character of the feeding punctures and likewise the shape of the larval cases.

In this study of the identification of mature scars it was found that the work of *Coleophora fletcherella* could not be distinguished at picking time from that of *C. malivorella,* and for economic purposes the injuries by both species may well be classed simply as case-bearer work.

The work of case-bearers on apples may usually be distinguished as follows: (1) by several small, rounded scars of different sizes appearing on one apple; (2) by some of the scars showing a funnel-shaped depres-

sion at the center; (3) in rare instances, when the wound has split and caused an irregular margin, by the distinctiveness of the funnel-shaped depression.

The fall webworm

(*Hyphantric textor* Harris)

The fall webworm is a well-known pest on forest and shade trees and at times may become abundant in apple orchards. The larvae begin making their unsightly webs on the branches of the trees during July, but these are more noticeable during August. The larvae of the fall webworm are essentially leaf feeders, but when they occur on apple trees their web nests frequently inclose a few apples. The larvae do not appear to prefer the fruit, but when apples come within their range they feed upon them. When abundant in an apple orchard the webworms may cause more or less damage to the fruit, not only by direct feeding on the apples but also by defoliation of the limbs, thus causing a stunting and shriveling of the fruit.

The work of fall webworms on two Alexander apples is shown in Plate XXVI, 104. All the leaves on the limb are brown and the fruits are covered with web and excrement. The larvae make broad, shallow feeding tracts over the surface of the fruit, but in places they feed more deeply. Two larvae may be seen in Plate XXVI, 102, feeding in cavities formed on an Alexander apple. The feeding always occurs so late in the season that healing of the wound never takes place. The scar surface usually shrivels and dries out considerably (Plate XXVI, 103). Unless the injured fruits have been purposely cleaned, the work of the webworm can always be recognized by the presence of web and excrement on broad, irregular, shallow scars which never heal.

The apple serpentine miner

(*Marmara pomonella* Busck)

An insect very interesting because of the peculiar habit of the larvae in making serpentine mines in the skin of the fruit, proved on determination to be *Marmara pomonella* Busck. This species was found working on the fruit from two localities in New York, but as yet it cannot be reckoned as a pest of economic importance. Two types of the serpentine mine made by the larva on Baldwin apples are well shown in Plate XXVII, 105 and 106. In one of these (106) the larva projected its mine in a circular course, causing a large blotch on one side of the apple; in the other, the larval mine proceeds in sinuous fashion all the way around the fruit. The larva works only between the epidermal and cuticular layers of the apple

skin, thus never causing injury to the flesh of the fruit. The damage, if such it can be called, is merely a matter of disfigurement of the apple. The serpentine mines are made during the latter part of the summer, after the apple has attained considerable size, and thus there is little opportunity for the insect to deform the fruit.

COLEOPTERA

The coleopterous pests on the fruit of the apple are few in number, and, excluding the work of a few occasional infestations by species that are general feeders, it may be said that only two species, both belonging to the Rhynchophora, are found to feed and develop larval stages in the fruit.

The plum curculio

(*Conotrachelus nenuphar* Herbst)

The plum curculio is known chiefly as a pest on plums and other stone fruits, but when these fruits are not available it may cause serious damage to apples. In one season the species may breed in large numbers on stone fruits, and in the following year, if there is shortage of plums and cherries, the beetles will migrate to the nearest apple orchard, there to begin their work on apples.

The plum curculio hibernates as an adult and comes forth in spring to the fruit trees, where it takes its first meal, and feeds until such time as young fruits are available on the tender, succulent growth. As soon as the apples set, the curculios begin feeding on them with ravenous appetite, and particularly is this true of the females, which are preparing to lay eggs. The early feeding punctures are in the shape of round holes in the skin of the fruit, through which the curculio excavates all the tender pulp that it can reach by inserting its long rostrum. In Plate XXVII, 107, is shown, slightly enlarged, a curculio resting on a young apple beside a typical feeding puncture that it has just completed. All the fruits injured in this manner were found to drop; since the fruit is so small and competition is great, few apples ever survive when injured at such a tender age.

After feeding for a few days, the female curculio is ready to begin laying eggs, and this is about the time when the apples are one-fourth of an inch or more in diameter (Plate XXVII, 108). The ovipositing female makes a small hole in the fruit just large enough to receive the egg, then deposits it and cuts a crescent-shaped slit extending in a semicircle around and obliquely beneath it. Such an arrangement doubtless prevents the egg from being crushed by growth pressure, and especially

protects the young larva at the time of hatching. Young fruits having egg crescents, and one with a feeding puncture, are shown for comparison in Plate XXVII, 109. Young apples in which curculio eggs have been deposited will fall to the ground, and if undisturbed the larva will develop to maturity. In fact, it seems to be necessary for the apple containing the eggs to fall to the ground if the curculio grub is to develop. Rarely are apples containing living larvae found on the tree, except late in summer when active growth has stopped, and such fruits would fall in any case before the larva had worked very far. It is apparent that a softening or shriveling of the fruit must occur before the grub is able to make much progress. Evidently vigorous growth and strong sap pressure in the fruit are more of a barrier to the curculio grub than to codling-moth larvae. The only apple containing an active burrowing grub that the writer has found on a tree, was found on July 13 on an unnamed variety (Plate XXVIII, 112). This fruit was not in an active state of growth, and probably would have dropped to the ground before the grub reached maturity. Perhaps the lack of sap pressure in the fruit, which permitted the curculio grub to start its burrow, was due to causes other than larval activity of the curculio. Certain it is that, in the majority of cases, the apple must be one that will drop to the ground from causes other than the presence of the curculio grub, or else the grub will never have an opportunity to develop.

The injuries caused by the curculio early in the season serve to thin out the fruit, but after the young apples have attained one-half inch or more in diameter many of them do not succumb to the influence of one or more egg punctures. Such fruits grow to maturity exhibiting scars, frequently being more or less deformed. Three young Baldwin apples with curculio scars which may or may not prove fatal to the development of the fruit, are shown in Plate XXVIII, 111. After June 20 a majority of the apples having egg punctures do not fall to the ground because of curculio injury, but recover and develop scars. On two of the fruits shown in Plate XXVIII, 111, a white exudation may be seen on the crescent flap, indicating that the larva has hatched and is making some effort to feed. Rarely does one find curculios that have come out of hibernation making simple feeding punctures after the middle of June, since in excavating each egg crescent a certain amount of pulp is eaten. In Plate XXVII, 110, a beetle is seen excavating a typical round feeding cavity, a result obtained by keeping the curculio in a jar where it could not feed for three or four days. The male curculio might be expected to make feeding punctures which would result in a scar slightly different from the well-known crescent of the egg-laying female. The males, however, apparently

feed so seldom following the first great feast, when the young fruits set, that rarely, if ever, can scars be found that would appear to have developed from plain feeding punctures.

In an experiment to get data on the feeding habits of the adults, a curculio was caged with a single apple from June 29 to July 6. The apple succumbed to the injuries and fell on July 20, with the result shown in Plate XXVIII, 113, photographed on July 21. Normally the apples that have received only a few egg punctures by the end of June or early July will recover and grow to maturity.

Many of the wounds made by the curculio on Roxbury apples during July were found to develop brown rot, as is shown in Plate XXIX, 116. Several of the punctures appear as rounded cavities, and probably represent the feeding work of newly emerged adults in the latter part of July.

The well-known crescent-shaped scars (Plate XXIX, 117) resulting from the work of the ovipositing female during the latter part of June are generally recognized at picking time. The typical crescent has one straight side, at the middle of which there is a projecting point representing the place where an egg was inserted. In many cases this distinctive egg mark does not show plainly, but an interruption of the straight margin at the middle can usually be distinguished.

Mature scars from six varieties of apples are shown in Plate XXIX, 117, in which the egg-puncture marks are seen in varying degrees of distinctness, these apples representing skins of different colors and textures. The Twenty Ounce apple shown in Plate XXVIII, 114, indicates how several curculio crescents grouped together may resemble the scars made by case-bearers, but an examination of the individual scars shows clearly the distinctive egg-puncture marks made by the female when ovipositing.

Perhaps the scars sometimes made by apple redbugs are the most likely to be confused with curculio work. An apple having scars of both curculio and redbugs is shown in Plate XXVIII, 115, for comparison. As pointed out above, however, there is little danger of confusing curculio feeding punctures with redbug work, for the distinctive egg crescents are invariably present on apples deformed by the curculio.

A study of the late summer scars made by the curculio revealed the fact that brown rot often results in the wounds. As was shown in the case of late codling-moth work, certain large species of muscid flies may enlarge the scars and assist in the development of brown rot, and this the flies clean out as fast as decay takes place (Plate XXX, 120 and 121). When undisturbed by flies the feeding punctures made by the curculio during August will develop brown rot, this producing a dark ring about the point of injury (Plate XXIX, 116).

Frequently one finds that tough-skinned varieties, such as Ben Davis and Jonathan, when grown under the right conditions will exhibit warting of the curculio scars (Plate XXIX, 119). Here again the scars can usually be identified by the presence of the distinctive egg-puncture marks.

The apple curculio

(*Anthonomus quadrigibbus* Say)

The common name of *Anthonomus quadrigibbus* would imply that it is primarily the curculio pest of the apple. It is not, however, as serious a pest on apples in New York as is the plum curculio. In certain localities *A. quadrigibbus* breeds abundantly on wild haws (*Crataegus* spp.), but in only a few instances was it discovered working on fruit in cultivated orchards. The apple curculio may be distinguished from the plum curculio by its long, curved rostrum, its elytra, broader toward the rear, and its four prominent humps (Plate XXX, 122).

The apple curculio was found to be so scarce in orchards of western New York, that in order to study the injuries of this species on standard varieties of apples the writer collected a large number of the adults from hawthorn, and these were placed in cages with apples for experimental purposes. Forty pairs of the beetles were placed in as many tarlatan cages, each inclosing two or more young apples. Many of the young fruits were stung to death, but after June 15 many apples would cling when stung only two or three times. In order to prevent the fruits from being injured excessively, the cages, with the beetles, were moved to new fruits every two or three days. Several curculios continued to feed and lay eggs on the fruit until the middle of July, but after that date the beetles died off rapidly.

As soon as the curculios were placed with the fruit they began feeding and laying eggs with unperturbed activity. In Plate XXX, 123 (photographed on May 28) are shown two female curculios on a young apple, in which one of them is laying an egg. After depositing the egg the female turned about, closed the opening to the cavity with her rostrum, and then moved to the tops of the stamens to have a look at the surroundings (Plate XXX, 124). The opening to both feeding and egg cavities appears merely as a rounded hole in the surface of the fruit. Through this opening the curculio thrusts its rostrum in order to excavate and eat the pulp, and frequently a rounded cavity is formed extending in all directions as far as the rostrum can reach (Plate XXX, 126). When excavating for purposes of oviposition only, the cavity may not be excavated so broadly. In order that the young grub may develop, the apple containing eggs must drop to the ground. Three or four stings on a fruit

will usually accomplish this result when there is competition among several fruits on one limb. After June 25, or when the apples have attained one-half an inch or more in diameter, many of the fruits will cling in spite of the punctures. No grubs were ever found to develop in the egg-laden apples that remained growing on the tree. Five Baldwin apples on which the beetles had fed and oviposited from June 25 to June 30, are shown in Plate XXX, 125, as they appeared when ready to drop on July 7; the punctures may be plainly seen, and the white exudation at the surface of some of them indicates that in those the young grub had begun activities.

The work of two curculios on a Baldwin apple after July 1 is seen in Plate XXX, 126, the apple being shown in section to expose the egg and feeding cavities. After July 4, very few apples, if any, that were in a strong growing condition when punctured, were found to drop and thus permit the grubs to develop.

One experiment performed was that of caging a pair of beetles from June 16 to July 6 with two Baldwin apples which were on a limb made free of all other fruits. These apples were able to withstand the injuries of the curculios, and grew to maturity with the result shown in Plate XXXI, 127. Another good illustration of the mature scars resulting from injury by the curculio is presented in Plate XXXI, 128, showing two Stark apples.

When growth of the fruit continues following the work of the beetles, the thin tissue and skin immediately above the egg or feeding cavity is found to dry out, usually leaving a white margin as shown in these two figures. A slight depression may result about the point of injury, due to the stoppage of growth, and the scar cavity itself always remains as a sunken brown spot. The most distinctive feature about the mature scar is the white-margined, dried-out tissue, resulting from the thin covering left immediately above the feeding or egg cavity.

The apple curculio was found at work on Bartlett pears in one orchard, making cavities similar to those observed on apples. When beetles were caged with pears, typical feeding and egg laying took place. The mature scars resulting from this experiment are seen in Plate XXXI, 129. The cavities made by the apple curculio on pears were filled out to a certain extent by subsequent growth, a result somewhat different from that obtained on all the apples observed.

The rose chafer

(*Macrodactylus subspinosus* Fabricius)

The adults of the rose chafer are general feeders, eating the fruit and the leaves of many kinds of cultivated and wild plants. The species

breeds in sandy pasture lands, where the grubs feed on the roots of grasses, and if orchards are located in the vicinity of such waste lands much injury may be done to the fruit when the beetles emerge and go forth in search of food and for mating. The writer had opportunity in 1914 to study the result of an invasion of an apple orchard by rose chafers in Genesee County, New York. The beetles were first observed at work on the fruit about June 20, and they continued to feed and mate on the apples until July 4, at which time it became difficult to find them. The trees that suffered the most were those bordering a sandy tract of pasture land, from which the insects evidently came to feed and to which they returned to lay eggs.

The rose chafers were found to eat large, irregular holes in the young apples, the cavity frequently being so large that one or more beetles could conceal themselves in it. Typical feeding scars on Baldwin apples are shown in Plate XXXII, 130, in which one beetle may be seen at work. It was found that the chafers frequently return to the old wounds for feeding, evidently preferring to do this instead of starting on a fresh apple; some beetles were observed to feed on wounds that were at least a week old. All fruits injured by rose chafers were found to shrivel up and drop during July, and so no scars resulted on the fruit. A group of apples showing typical injuries is shown in Plate XXXII, 131, as photographed on July 3; certain of these fruits were injured ten days previous to the time when the picture was made and appear greatly shriveled, while others, which were injured on a later date, indicate how the margin of the wound first shrinks and then curls inward, to be followed perhaps by brown rot. A few days later the same fruits would appear similar to the ones shown in Plate XXXII, 132, which have shriveled and dried out until they are scarcely recognizable. It is apparent that the irregular, rough wounds made by rose chafers feeding on apples are of such character that healing is impossible, and sooner or later the injuries become infected with brown rot, eventually causing the fruits to shrivel and dry up.

DIPTERA

Dipterous pests on the fruit of the apple are few in number, and only one species, the apple maggot, breeds in the fruit and causes economic losses. Ripe apples, and particularly summer varieties, are frequently damaged considerably by swarms of large muscid flies which sip at any point of rupture occurring on the surface of the fruit. Eventually large cavities are produced, and with the introduction of brown rot, decay of the apple is rapid.

The apple maggot

(*Rhagoletis pomonella* Walsh)

In New York the apple-maggot flies may appear in the trees early in July, and when late summer spraying is not practiced the flies soon begin inserting their eggs through the skin of the fruit (Plate XXXIII, 133). The egg puncture appears as a tiny speck, and in those varieties whose growth is not yet completed, a small dimple may form about the point where the egg was inserted (Plate XXXIII, 134). As soon as the apple begins to mellow, the tiny maggots begin to burrow through the pulp in all directions. The maggot works slowly until the apple softens in the ripening process, when it begins to grow rapidly, making winding tunnels through the pulp and quickly reducing the inside of the fruit to a brown pulp (Plate XXXIII, 135). In certain localities where the flies are uncontrolled, the fruit of several summer varieties may be rendered entirely useless.

Maiden Blush apples are grown for the market on a considerable scale in western New York, and in a few orchards, where late summer spraying for the codling moth was not done, the apple-maggot flies began to increase rapidly. A typical example of apple-maggot work on this variety may be seen in Plate XXXIII, 135, photographed in section to show the extent of the tunneling by the maggots. The section on the right exhibits the emergence holes of the mature maggots, brown rot having developed about each tunnel and spread to destroy the whole fruit. A second apple cut in section (Plate XXXIII, 136) illustrates more clearly the tunnels before the brown rot has reduced the pulp to a brown mass, and in this figure mature maggots may be seen as they appear when ready to emerge. Brown rot invariably develops in the maggot tunnels, and this condition appears to be very favorable for development of the maggots.

The apple-maggot fly may lay eggs freely in standard varieties of apples when such apples occur where the flies have become numerous on more favorable fruit. But in such cases the maggots do not develop very rapidly until the ripening process has softened the pulp. The Tompkins King is a variety that becomes sufficiently mellow shortly after being picked to allow the maggots to complete development even after the fruit is packed in barrels. A Tompkins King apple which was bought in the market in October and which appeared to the average consumer as desirable fruit, was packed away until the end of November, with the result shown in Plate XXXIV, 139. On November 29 some of the maggots had emerged, and brown rot could be seen as a discoloration on the surface, indicating that the inside of the apple was practically destroyed. Another Tompkins King apple, from which only two maggots emerged,

is shown in Plate XXXIV, 137. In this case so few maggots were at work that brown rot was much delayed in destroying the fruit. The photograph was made just four days after a maggot had emerged from the hole that is surrounded by brown rot.

In Genesee County the writer found the apple maggot breeding freely in crab apples, a condition developing perhaps from the fact that in that locality this variety of fruit rarely, if ever, received the late summer sprays usually given the commercial orchards. In crab apples that are infested, dark tunnels may be seen just beneath the skin, and fruits that are cut in section exhibit typical work of the maggots (Plate XXXIV, 141). The crab apple is firm of flesh and very acid, and this prevents the maggots from making progress until the fruit has lain on the ground for two or three weeks. Crab apples drop freely from the tree and large numbers are usually permitted to remain on the ground to decay, and this condition promotes development of the apple maggot on this fruit.

In some localities it may happen that the apple-maggot flies have developed in considerable numbers on early summer varieties of apples and a second brood emerges to oviposit during September. Either the flies of a second brood or the retarded members of a single brood may attack standard varieties of apples during late September, and the tiny punctures made by the ovipositor will appear as small, black specks from which few or no maggots develop. These spots may be identified by making a section through the puncture, which will usually reveal an egg or a tiny cavity where an egg had been placed.

An interesting case of late oviposition by apple-maggot flies, perhaps the late oviposition work by individuals of a single brood, may be seen in Plate XXXIV, 140, showing a Baldwin apple photographed in October. The punctures made by the ovipositor were situated in small depressions, as is usual, but each incision was surrounded by a dark greenish color of unusual character. A pathological examination of the spots revealed the fact that both the black rot fungus (*Physalospora Cydoniae*) and the New England fruit spot (*Phoma pomi*) had entered and developed in the punctures, probably coming as an infection on the ovipositor of the female fly. The spots produced by stippen, a physiological condition, may sometimes superficially resemble the oviposition marks of the apple-maggot fly, but with the aid of a hand lens one can always recognize the punctures made by the female ovipositor.

HYMENOPTERA

Only two insects in the order Hymenoptera were found affecting the fruit of the apple, and these are rarely present in sufficient numbers to cause economic losses.

The apple-seed chalcis

(*Syntomaspis druparum* Boheman)

The damage done by the tiny apple-seed chalcis to the fruit, slight as it may be, is caused by the female when she inserts her long ovipositor through the pulp in an effort to reach the seeds. The work of the seed chalcis is found only on crab apples and Lady apples, for these are the only cultivated apples that are sufficiently small to permit the female to oviposit in the seeds. The female chalcis is interested merely in placing her egg in the apple seed, where the maggot will develop and remain to pass the winter. The puncture made by the ovipositor leaves a mark on the surface of the apple (Plate XXXIV, 138) which strongly resembles the oviposition scars produced by the apple-maggot fly. Both the apple-seed chalcis and the apple-maggot fly may work on the same fruits, but the individual punctures of the two species are distinguishable by a careful examination of the wound. If the scar is that of the apple-seed chalcis, a section through the puncture to the core will show a slight discoloration and scar along the path followed by the ovipositor (Plate XXXIV, 142). On mature fruits the work of the chalcis fly may otherwise be identified by an examination of the apple seeds, which will show the presence of the larvae. Frequently it may happen that the apple-seed chalcis may breed and become so abundant that crab apples are much stunted and disfigured through the numerous wounds produced by excessive oviposition.

The dock false-worm

(*Ametastegia glabrata* Fallén)

A rather unusual type of injury to mature fruit on the tree has been recorded in Canada as the work of a sawfly larva, *Ametastegia glabrata* Fallén. In the fall of the year the mature larvae desert their wild food plant and go in search of suitable hibernation quarters. When this insect occurs near the apple orchards it may so happen that the larvae will climb up the trees and eat holes in the fruit, excavating cells just large enough to make comfortable hibernation quarters. The writer found an example of this peculiar injury at Ithaca, New York, and a photograph of the sawfly larva in its cell is shown in Plate XXXV, 143. The larva excavates a hole in the flesh of the apple, in depth slightly greater than its own length, thus forming a cell, the opening being closed by bits of the excavated pulp. This insect will probably never cause trouble in well-kept and cultivated orchards.

INJURIES TO THE FRUIT OF THE APPLE BY AGENCIES OTHER THAN INSECTS

The preceding part of this paper deals with specific types of injuries caused by insects, but the person who has occasion to grade or to inspect apples will meet with many other peculiar and little-known scars. In order to recognize all scars arising from insect activities, it was necessary to take into consideration all types of injury that may be found on the fruit. The more important and more frequently met types of injury caused by agencies other than insects, are discussed in the following pages.

WARTING OF SCARS

The peculiar phenomenon exhibited by scars that bulge out beyond the normal surface of the fruit has been designated as *warting* of the scars. The writer has seen this warting produced in scars made by redbugs (Plate XXXV, 144 and 145), by curculios (Plate XXIX, 119), by fruit-tree leaf rollers, by green fruit worms, by tussock moths (Plates XXI, 83 and 84, and XXXV, 146), by apple scab, and by frost injury (Plate XL, 168). It is apparently because of unusual growing conditions that the injuries caused by these several agencies produce the abnormal bulging growth under the scar. This warting of the scars produces peculiar results in some cases (Plate XXXV, 146), and may be explained by accelerated growth late in the season. After the middle of August, apples usually grow very slowly, but occasionally favorable rains after that date force new and rapid growth. When growth is accelerated in the fruit, it is apparent that considerable pressure is exerted on the old and more or less hardened skin. Scar tissue when present, being the most recently formed and tender, gives way first, and new cells are formed beneath the area. In tough-skinned apples such as the Ben Davis (Plate XXXV, 146), the new growth is forced the most completely through the newly formed scar tissues.

MECHANICAL INJURIES

Apples frequently become scarred by rubbing against limbs and by striking stubs or sharp limb ends. In Plate XXXVI, 147, is shown a Rhode Island *Greening* apple which was rubbed constantly by a limb just underneath, from the time it was an inch in diameter until picking time. The russet area is covered with checkered spots of thickened brown corky tissue, all of which was highly polished by the rubbing limb. A Baldwin apple which was blown frequently against a sharp stub is shown in Plate XXXVI, 148. The effect in this case was that holes were punched in the skin of the fruit. A very similar example, only that the punctures were made by a very sharp stub, is shown in Plate XXXVI, 149. Some of the

early wounds healed much as do the scars produced by redbugs, but the later injuries produced a different scar. When the fruit rubs against a limb and there are no sharp points to break the skin, a rough russet surface may be produced on the skin. In another case observed, a Baldwin apple rubbed against a stub from the time it was one-half inch in diameter until it had grown to be one and one-half inches in diameter, when the obstruction was removed. The mature scar (Plate XXXVI, 150) resembled somewhat the scars resulting from slight injury by lime-sulfur spray, but the russet surface was more restricted to a definite area on one side of the fruit than would have been the case with spray burn.

EXPERIMENTS IN PRODUCING SCARS BY PIN PUNCTURES

The peculiar spreading scars that develop on apples injured by feeding redbugs led the writer to experiment on the fruit with fine pin punctures, to ascertain whether the mechanical punctures alone would produce the same type of scar.

In making feeding punctures, *Lygidea mendax* may inject into the wound a poison which affects the fruit differently from ordinary punctures. The peculiar festering noted in the wounds made by feeding redbugs, and their subsequent development, are so characteristic that it seems very probable that some secretion of the bug plays an important part. The writer made dissections of nymph and adult heads of *L. mendax* in an effort to locate poison glands, but if such were present they were so small that he failed to find them.

The bug when feeding will at intervals raise and lower its proboscis in the wound, evidently lacerating the pulp cells in order to obtain a greater flow of sap. Experiments in imitating redbug wounds were made by using a No. 0 insect pin to make the punctures. On June 7, when the young apples were not more than a half inch in diameter, a large number of fruits were treated in this way. The mature result of some of these pin punctures on a Rhode Island *Greening* apple is shown in Plate XXXVI, 151. The pin punctures did not produce a characteristic festered wound such as is made by redbugs, with the subsequent splitting of the adjacent skin and development of russet scars.

CRACKING FRUIT

One frequently finds apples that are circumscribed by large and extensive cracks, and in most cases these appear to be the result of steady growth. In all cases it would appear that cracks on the surface of the fruit are due to a hardening of the skin before the normal size of the apple is attained. When the skin loses its ability to expand and take care of the increase of size required by growth, the natural result is the forma-

tion of cracks on the surface to permit of the necessary increase in size due to growth pressure within. The Roxbury is an apple which frequently exhibits cracks, and this might be expected, due to the unusual type of skin that this variety possesses (Plates XXXVI, 152, and XXXVII, 153). Certain fruits that have been excessively scarred by insects may develop cracks in the dry, hard skin as a result of expansion by later growth. Two Rhode Island *Greening* apples which were largely covered by the broad russet scars resulting from redbug injury, developed cracks as shown in Plate XXXVII, 154, photographed in August. An interesting example of the habitual development of large, broad surface cracks was to be found on a Baldwin tree, one large limb of which always produced fruit with a thick russet skin and broad cracks (Plate XXXVII, 157). That part of the tree which produced these strange russet apples, so unlike the typical Baldwin apples that grew on other parts of the tree, was evidently a sport development and always produced fruit with a thick, tough skin that must necessarily crack during growth.

LIME-SULFUR SPRAY INJURY

Lime-sulfur spray as ordinarily used — 1 to 40 — will, if the young fruit is drenched, cause slight burning, but the extent of injury depends much on the variety affected. The Tompkins King apple is particularly tender, and it is this variety that shows oftenest the effects of spray injury (Plate XXXVIII, 158). In many cases the injury results in russet scars which in some respects may resemble the work of redbugs. In Plate XXXVII, 156, is shown a perfectly shaped Baldwin apple which has typical russet scars produced by slight burning from lime-sulfur at the time of the calyx spray. This type of scar may usually be recognized by the many fine and irregularly placed russet streaks and cracks.

SUN-SCALD

Sun-scald is the name usually applied to the excessive burns that may result from late summer spraying when the sunshine is bright and the atmospheric temperature high. A good illustration of this was observed in 1914, when spraying was done on August 4 and August 5 for the second brood of codling moth. On both days the sunshine was very hot and the temperature ranged from 90° to 100° F. All apples that were well covered with the spray and then exposed to the sunshine for three or four hours developed a characteristic burn. Four days later, or on August 9, the results of the sun-scald attracted attention. Two Rhode Island *Greening* apples as picked are shown in Plate XXXVIII, 160; the dark color of the scalded spots shows through the coating of arsenate of lead and lime-sulfur. In the case of Baldwin apples that developed sun-scald, the dark scalded area showed clearly in contrast with the red color of the

fruit. The cells beneath the scalded spots were killed to a depth of from one-eighth to one-fourth inch, and turned dark brown within four days after the burn occurred. A section through a scald spot on a Baldwin apple, which was typical of the average burn, shows the brown color penetrating to not more than one-eighth inch (Plate XXXVIII, 159). One of the same Baldwin apples is shown in Plate XXXVIII, 161, with a mature scald scar as it appeared on October 21. The burned tissue turned brown and dried out, only to be followed later by the formation of large cracks in the dead tissue.

SCARS PRODUCED BY FROST INJURY

The writer observed that frost injury to young apples may develop into scars that very much resemble the large russet scars made by redbugs. The spring of 1915 was a season when frost was noted in many localities in western New York. A frost occurred on the morning of May 28, which was soon after the young apples had set. The apples that recovered from the injury developed a characteristic scar band, usually extending around the middle of the fruit but in some cases appearing either nearer the base or toward the calyx (Plates XXXIX, 167, and XL, 171). The first apples observed to be recovering and exhibiting effects of freezing were found on June 16 (Plate XXXVIII, 162). The apples that were killed by the frost were dropping off rapidly on the same date. Many orchards that were situated in valleys had all the fruit killed, while other orchards, located on hillsides, had only part of the fruit killed. In some places it was possible to locate within a few inches the highest point that the frost level reached. In such orchards one could find fruits exhibiting all stages of freezing, which were indicated later by corresponding scars on the apples that recovered. A Northern Spy apple from an orchard in which nearly every apple was killed is shown in Plate XXXIX, 163; practically the whole surface is covered with russet, and during later stages of growth several large cracks occurred in the skin.

Scars resulting from frost injury can usually be recognized by the splitting of the skin along the axis of the fruit, which makes the scar band uneven (Plate XL, 168 and 169). Many fruits, however, exhibit practically a continuous band of russet which corresponds to the surface that was frosted on the young apple. The location of the band has much to do with the growth of the apple and its shape at maturity (Plate XXXIX, 166 and 167). Certain apples were only slightly frosted, and in these cases the scars appeared in only two or three places around the circumference of the fruit. In such fruits the scars were sometimes difficult to distinguish from the injuries produced by redbugs. Isolated frost scars always appear as splits along the axis of the fruit (Plate XL, 168),

while the scars produced by redbugs are very irregular and extend in all directions. Frequently the splits occurring along the axis of the fruit are reduced to four or five in number and are grouped at one end (Plate XL, 169). The seeds were always killed in badly frosted apples, and many apples that grew to large size exhibiting frost bands were found to contain only one or two seeds. Frost bands were even distinguishable on the surface of russet apples. In Plate XL, 170, three Golden Russet apples are shown with typical frost bands and cracks, the extent of which may be readily recognized on the normal russet surface.

In those orchards where the frost was most severe and all the fruit was apparently frozen, it was possible to find clusters of stunted, russet-covered apples wherever the rosy aphid had developed and was present on the cluster at the time when the frost occurred. These fruits were worthless, but were of interest as indicating the influence the aphids had in causing the frozen fruit to cling through the growing season.

HAILSTONE INJURY

The scars resulting from hailstone injury may assume various shapes and forms. On isolated fruits such scars are in some cases difficult to distinguish from certain insect scars. If the hailstone injury occurs early in the season, while the fruit is growing rapidly, many of the apples will recover and exhibit scars that resemble somewhat the work of tussock-moth larvae or the very early intermittent feeding of the green fruit worms. An apple having four hailstone scars which were inflicted early in July, and one small scar produced by a green fruit worm in June, is shown in Plate XLI, 176 (photographed on August 23). The hailstone scars invariably exhibit a considerable amount of dead, corklike tissue resulting from the drying-up of the injured cells. In the case of Baldwin apples observed, which were injured by hail on July 20 and examined on September 25, the bruised cells were found to turn brown, dry out, and then crack and fall away. Usually some of the corklike cells are left clinging to the inside of the pit.

A Baldwin apple that was injured on July 20 is shown in Plate XLI, 173, as photographed on August 4; deep-sunken pits were produced, and the cells immediately beneath the scars turned brown and dried out. Sections at two different levels immediately beneath such spots are shown in Plate XL, 172, indicating the depth of the wound and the way the tissue dries out. A Baldwin apple which was injured by a large angular hailstone is seen in Plate XLI, 174. Baldwin apples severely injured by hail on July 20, exhibiting large, angular scars more or less filled with the dead and dried-out tissue, are shown in Plate XLI, 175 and 178, in the

stage of recovery that was attained by August 17. Even crab apples, small as they are, may show the same type of ugly wounds due to hailstone injury as are found on the standard varieties of apples (Plate XLI, 177).

APPLE SCAB

Apple scab causes much injury to apples even in orchards that are well sprayed, and is a factor that often enters into combination with other scars to disfigure the fruit. Typical scab spots usually exhibit a characteristic papery edge around the margin of the scar, which represents the cuticle of the skin that is left by the fungus (Plate XLII, 179). After a time the scab spots may lose this character and appear as dark-colored, irregular blotches. Late scab infection occurring during early September, may cause red color to develop around the point of infection, thus giving a superficial resemblance to San José scale (Plate XII, 37). Very soon, however, the scab spots grow larger and acquire a characteristic dark color at the center (Plate XLII, 181). The old scab scars may become smooth and even russet-colored by the time the fruit is matured, and when conditions are right for producing growth late in summer, warting of the scars may take place. An excessive amount of scab grouped on one side of the apple may dry out the surface to such an extent that large cracks will appear (Plate XLII, 180).

STIPPEN

Large and over-grown Baldwin apples may frequently exhibit small, discolored spots, somewhat resembling the spots from which scale insects have been removed. Such imperfections are caused by a physiological disease known as stippen. When a stippen spot occurs in connection with an enlarged lenticel of the skin, it may be somewhat suggestive of an oviposition mark made by the apple-maggot fly. A section through such spots, however, will reveal the true cause. Stippen may be recognized in section by the numerous brown discolorations caused by the dying and drying-out of groups of cells throughout the flesh of the fruit, and particularly at the surface (Plate XLII, 182).

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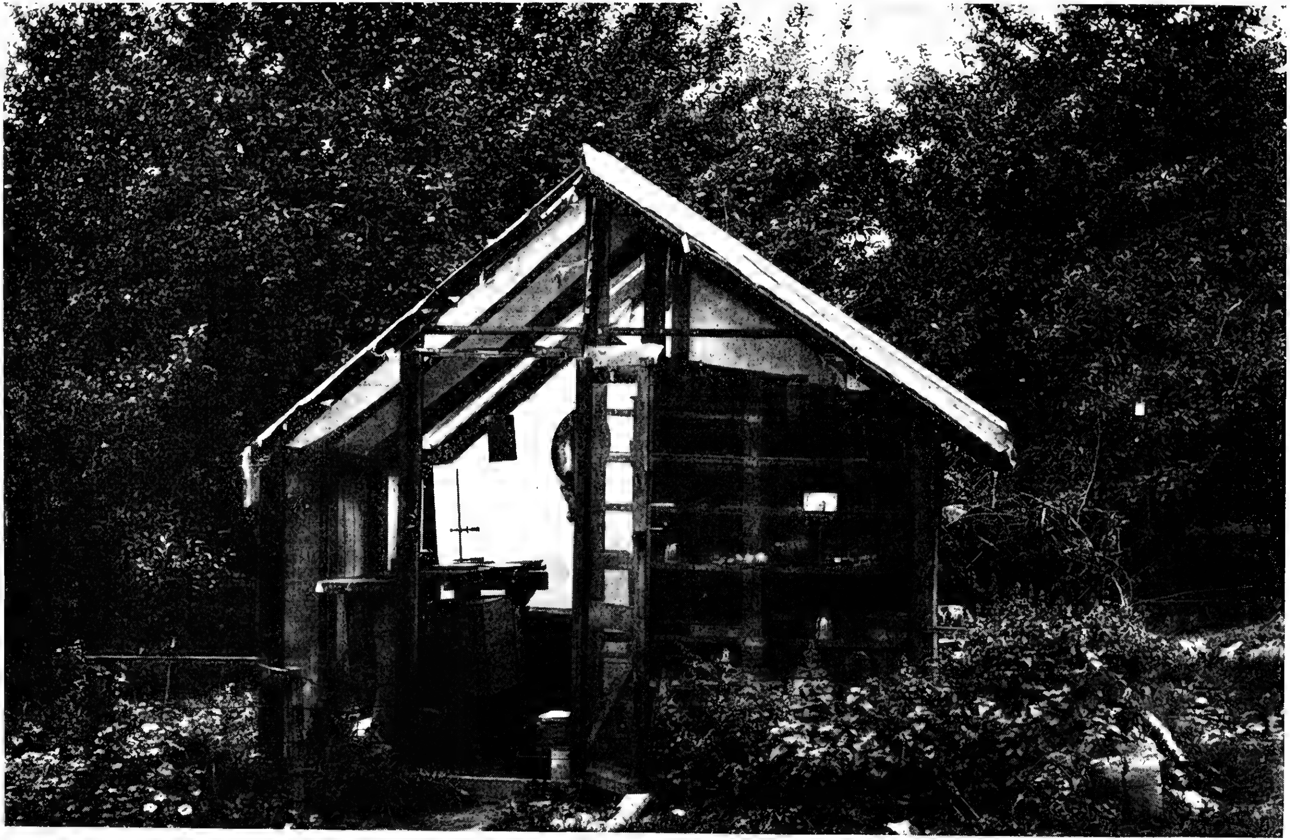


THE FIELD INSECTARY AT BATAVIA, NEW YORK

This was equipped with skylight and dark room, and served in the production of practically all the negatives from which prints were made for this thesis

Plate IV

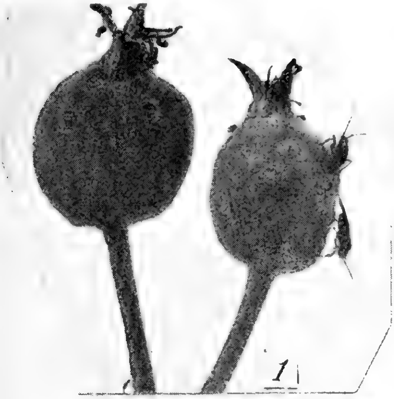
INJURIES PRODUCED BY LYGIDEA MENDAX

1, Rhode Island *Greening* apples with nymph and adult redbugs, showing the injuries they produce. Photographed on June 18

2, Redbug injuries on Northern Spy apple. The scars are spreading and joining one puncture with another. Photographed on July 8

3, Northern Spy apple showing mature scars which on July 8 were very similar to those shown in figure 2. Photographed on September 22

4, Rhode Island *Greening* apple (at left) and Tolman apple (at right), showing typical deeply pitted redbug injuries on the mature fruit. Photographed on October 21



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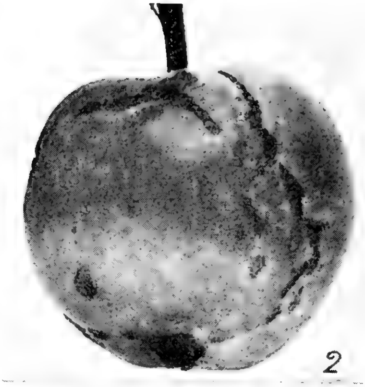

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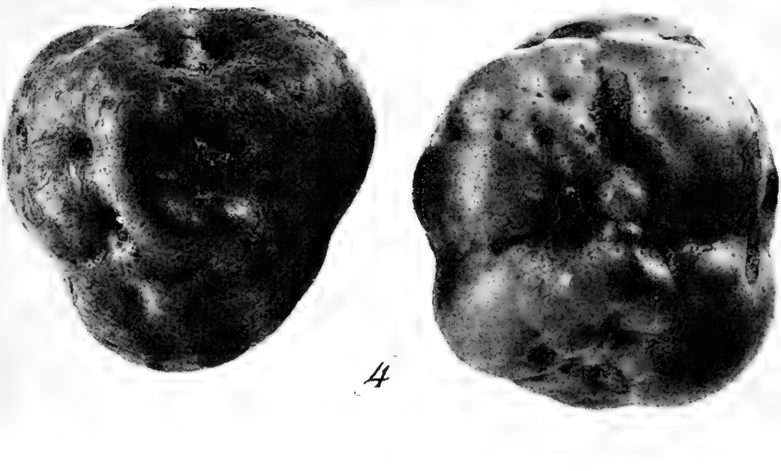

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Plate V

INJURIES PRODUCED BY LYGIDEA MENDAX

5, Baldwin apples showing the beginning of russet scars, the punctures having been made from seven to ten days earlier by the feeding redbugs. Photographed on June 24

6, Baldwin apples showing the development of russet scars on July 3, practically two weeks after the punctures were made by the feeding redbugs

7, Roxbury apples in section, showing the condition of the tissue surrounding points of puncture made by redbugs in June. Photographed on August 30

8, Northern Spy apple showing the deep pits resulting where redbugs fed on the fruit and made punctures that reached the core. Photographed on August 25

9, Mature Rhode Island *Greening* apple showing a few deep pits resulting from redbug punctures which are very suggestive of plum curculio work

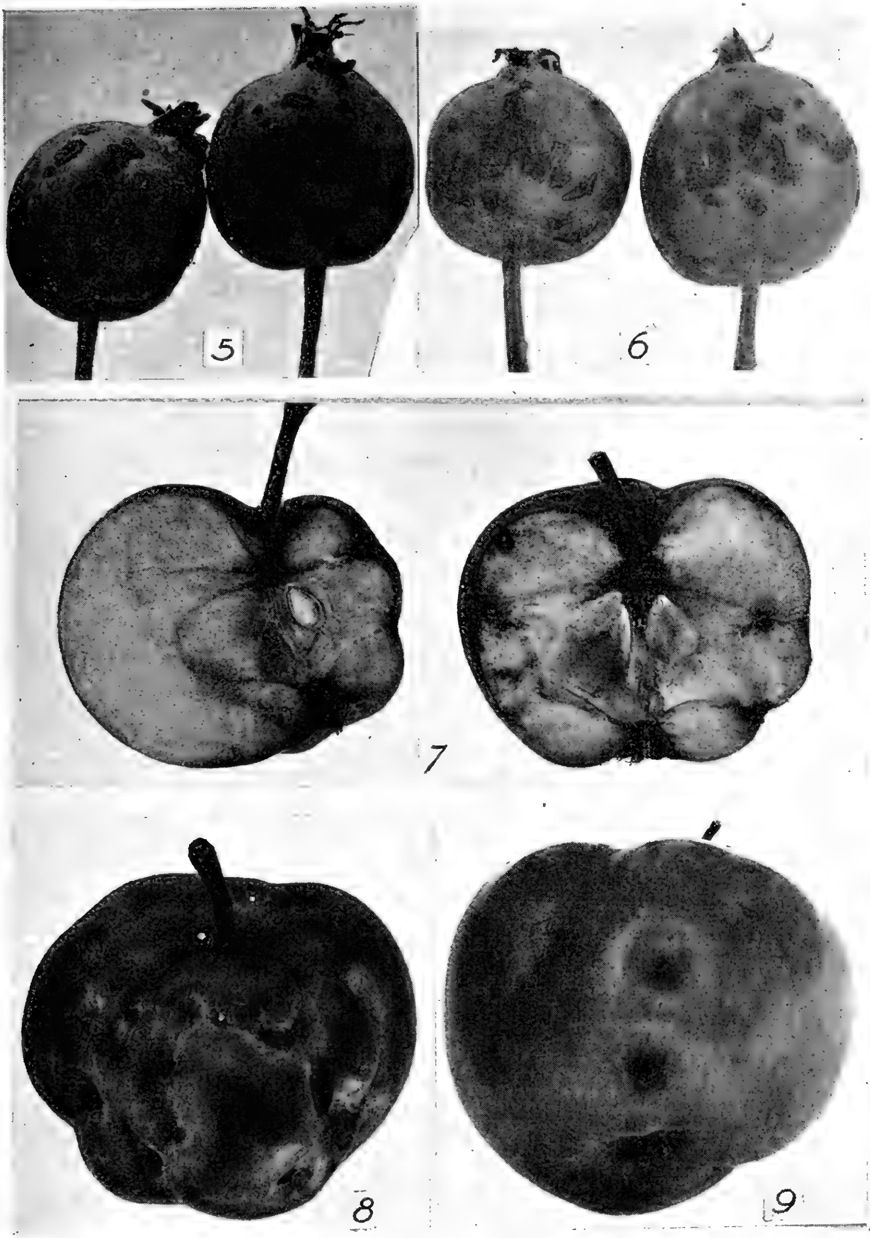
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Plate VI

INJURIES PRODUCED BY LYGIDEA MENDAX

10, Maiden Blush apple showing the scars resulting from the feeding of adult redbugs. Photographed on September 20

11, Tolman apple showing the mature scars resulting from feeding punctures of adult redbugs. Photographed on October 23

12, Mature Northern Spy apple illustrating the result when redbug punctures that have reached the core tissue occur along one or two definite lines

13, St. Lawrence apple on which the russet type of redbug scar changes to smooth, brassy, russet-colored scars. Photographed on July 28

14, Rhode Island *Greening* apple photographed on July 7, showing character of scars on that date

15, Golden Russet apples showing deep pits and russet scars caused by redbugs. Photographed on July 13

16, Work of redbugs on natural fruit, exhibiting all types of scars. Photographed on July 6

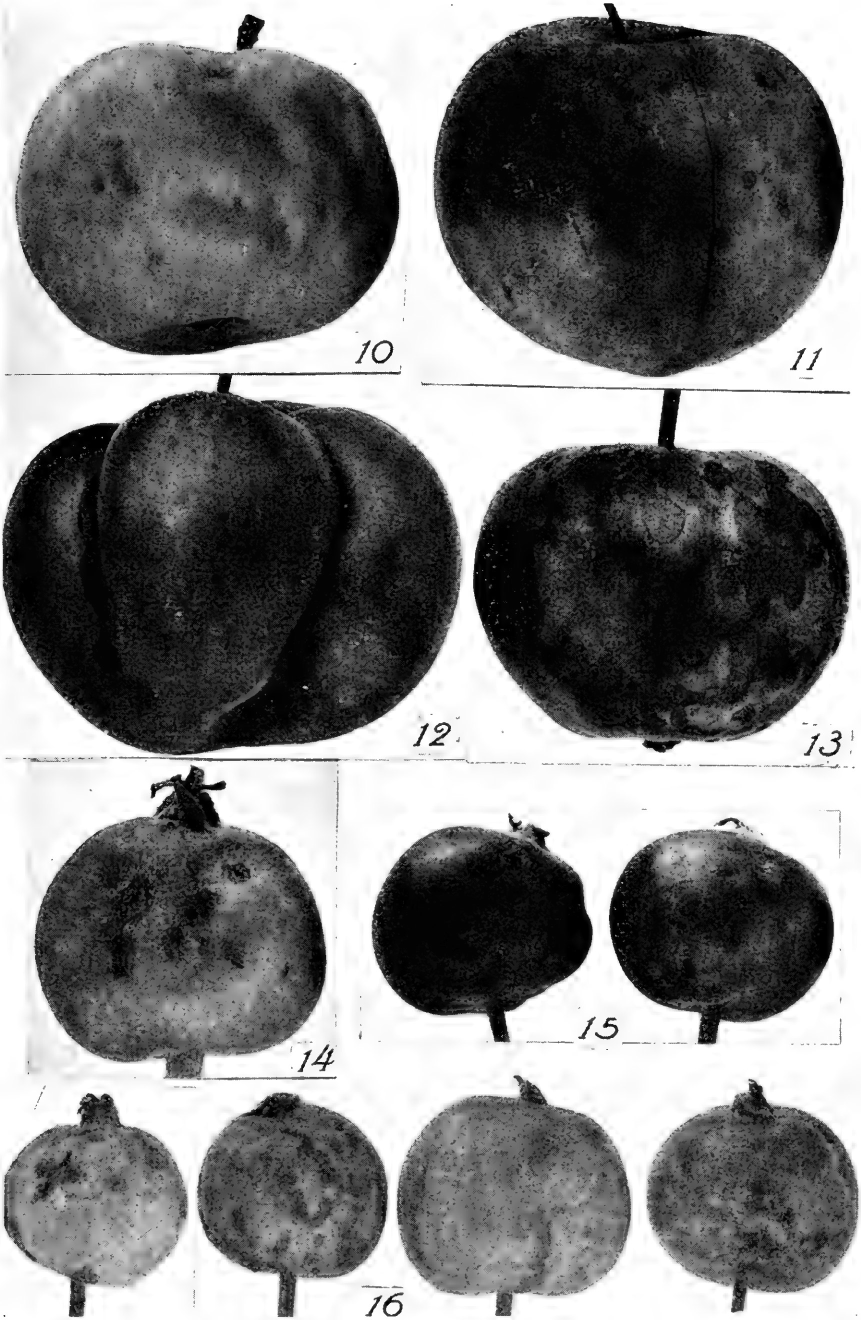
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Plate VII

INJURIES PRODUCED BY LYGIDEA MENDAX AND BY APPLE SCAB

17, Rhode Island *Greening* apples showing an early stage of redbug scars, photographed on July 7 for comparison with apple scab spots shown in figure 18

18, Apple scab spots photographed on July 7 and shown for comparison with redbug scars

19, Roxbury apples showing both the pitted and the russet type of scars, the russet scars being little different from the natural skin of the fruit

20, Mature russet scars caused by feeding redbugs on an unnamed variety of apple having a polished, light-colored skin. Photographed on September 25

21, Baldwin apple which was badly injured by feeding redbugs in June but recovered and grew to maturity exhibiting russet scars. The remains of a young apple that was killed by the feeding bugs may be seen

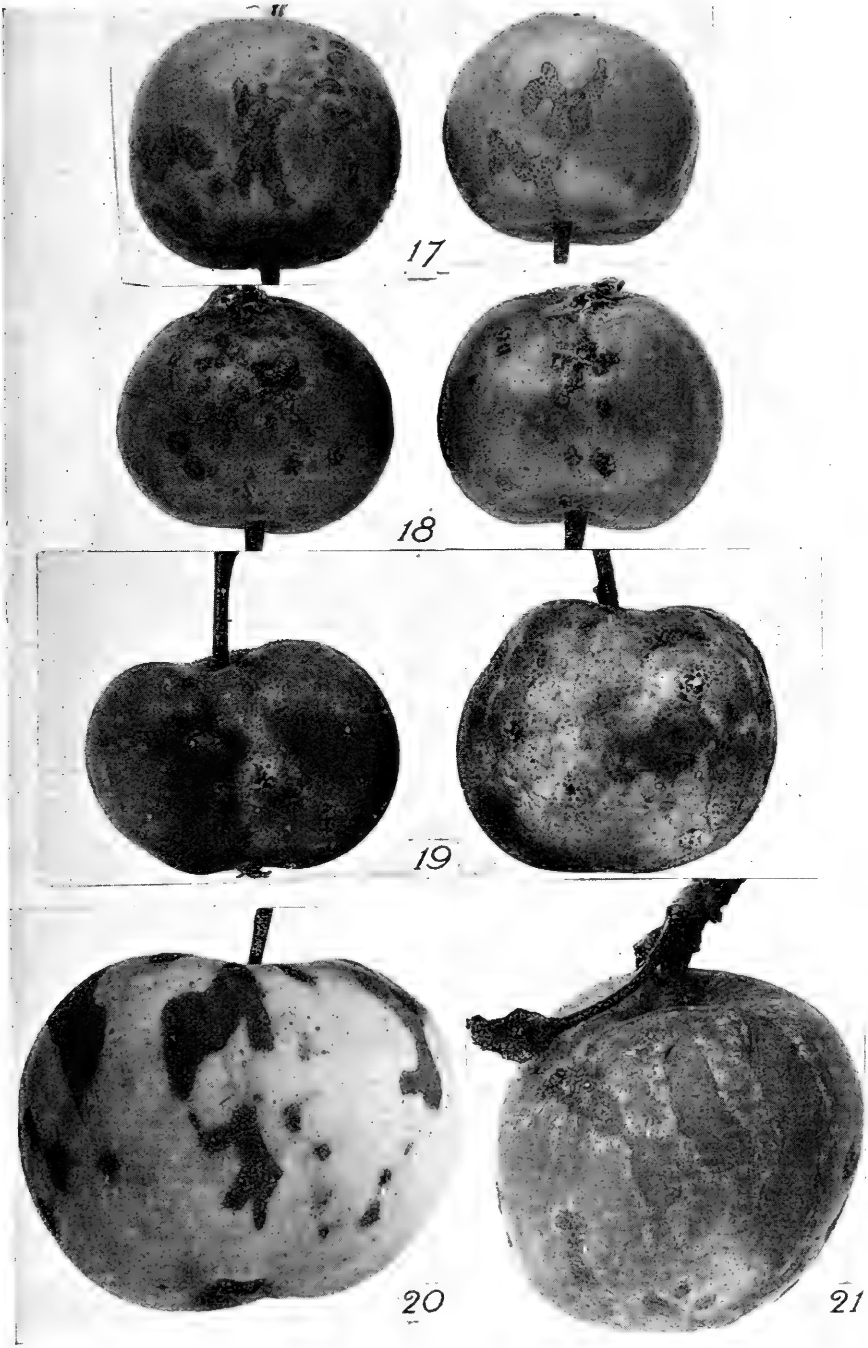
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Plate VIII

INJURIES PRODUCED BY LYGIDEA MENDAX AND BY APHIS SORBI

22, Baldwin apple, perfect in shape but showing the more or less smooth, russet type of redbug scars. Photographed on Septemb r 27

23, Roxbury apple punctured by feeding redbug nymphs in June. This developed into a perfectly shaped fruit, but it exhibits russet scars which show in contrast with the natural russet color of the fruit. Photographed on September 7

24, Baldwin fruits that were severely injured by feeding redbugs, followed by an infestation of *Aphis sorbi*. Such wounds become enlarged by the action of the aphid, exhibiting a frothy exudation and an enlargement of the scar by the splitting of the skin at certain points. Photographed on June 25

25, Rhode Island *Greening* apples photographed on September 21, which on June 25 were in a very similar condition to the fruits shown in figure 24, fruits that were first punctured by redbugs and then suffered from an infestation of *Aphis sorbi*

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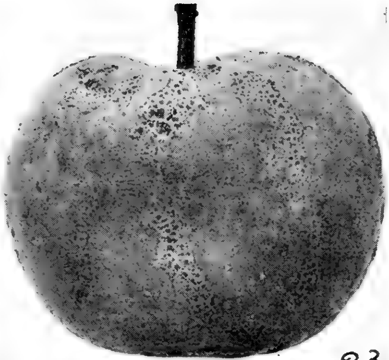

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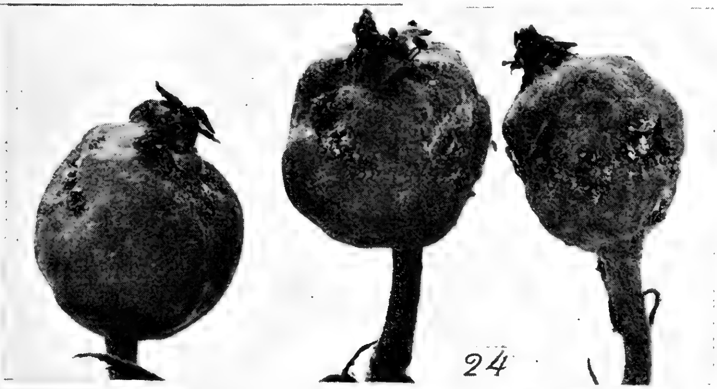

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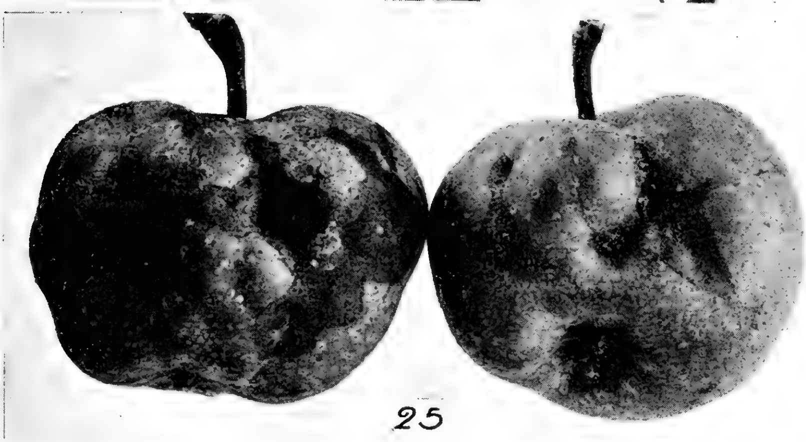

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Plate IX

INJURIES PRODUCED BY LYGIDEA MENDAX, HETEROCORDYLUS MALINUS, AND APHIS SORBI

26, *Heterocordylus malinus.* A female bug, heavy with eggs, feeding on a young apple. Photographed on June 18

27, Mature quinces photographed on September 18, showing the scars resulting from the feeding of redbug nymphs of *Lygidea mendax* in June

28, A Twenty Ounce apple, and a slice from a second fruit, which show the mature scars caused by redbugs. In all probability this is the work of *Heterocordylus malinus*

29, A cluster of six Baldwin apples, photographed on June 24, showing typical work of *Aphis sorbi* at that date

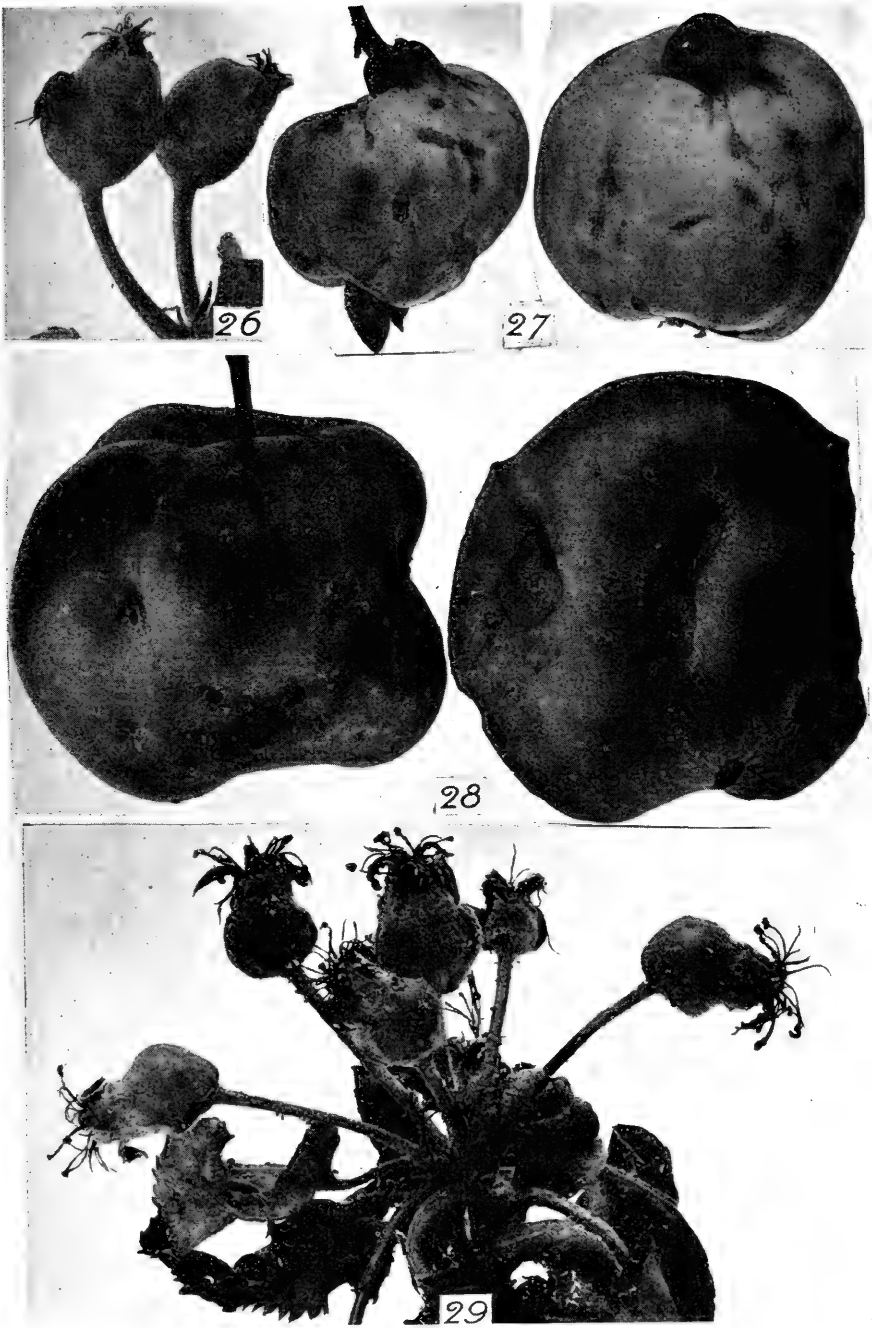
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Plate X

INJURIES PRODUCED BY APHIS SORBI

30, A cluster of six Baldwin apples which were infested by *Aphis sorbi* in June and photographed on the tree on July 4

31, The same cluster of apples as is shown in figure 30, as they appeared at the end of the growing season. Photographed on September 25 (nearly natural size)

30

31

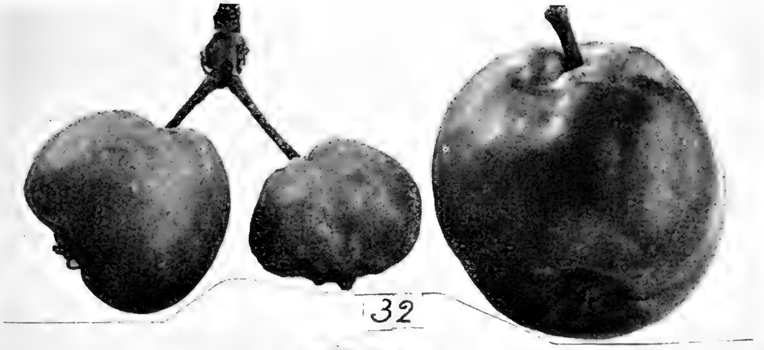
Plate XI

INJURIES PRODUCED BY APHIS SORBI AND BY A. POMI

32, Pippin apples showing a puckered appearance at the stem end, or base of the fruit, a condition usually seen only at the calyx end and resulting from an infestation of *Aphis sorbi*

33, A cluster of Baldwin apples which were first infested with *Aphis sorbi,* followed by *Aphis pomi* during the period between June 25 and July 20. The dark, smutty appearance results from the work of a fungus on the honeydew secreted by *Aphis pomi.* Photographed on August 4

34, Apples showing the black, smutty appearance that results from the development of a fungus on the honeydew secreted by *Aphis pomi.* Photographed on August 4



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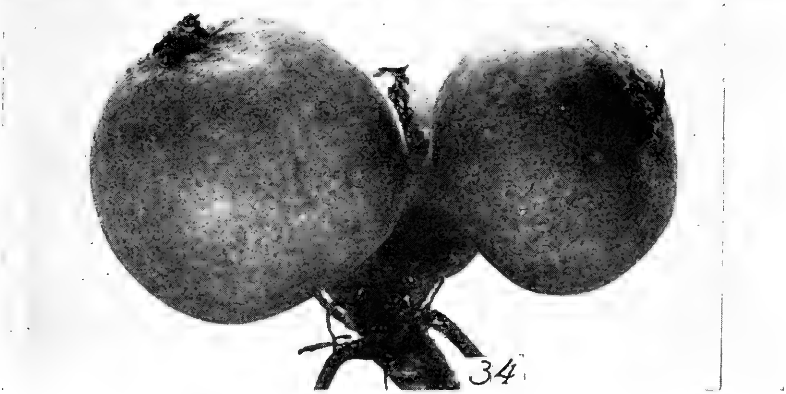

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Plate XII

INJURIES PRODUCED BY ASPIDIOTUS PERNICIOSUS, APPLE SCAB, AND CARPOCAPSA POMONELLA

35, Baldwin apple which shows a heavy infestation of San José scale on the calyx end of the fruit. Photographed on November 29

36, Mann apple showing the characteristic development of red color about the scales. Photographed on November 29

37, Maiden Blush apples which developed late scab infections and show color about the scab spots, superficially resembling the spots made by San José scale. Photographed on September 18

38, Baldwin apple cut in section, showing a mature codling-moth larva in its burrow. Photographed on July 8

39, Rhode Island *Greening* apple in section, showing a typical burrow and the nearly full-grown codling-moth larva. Photographed on August 4

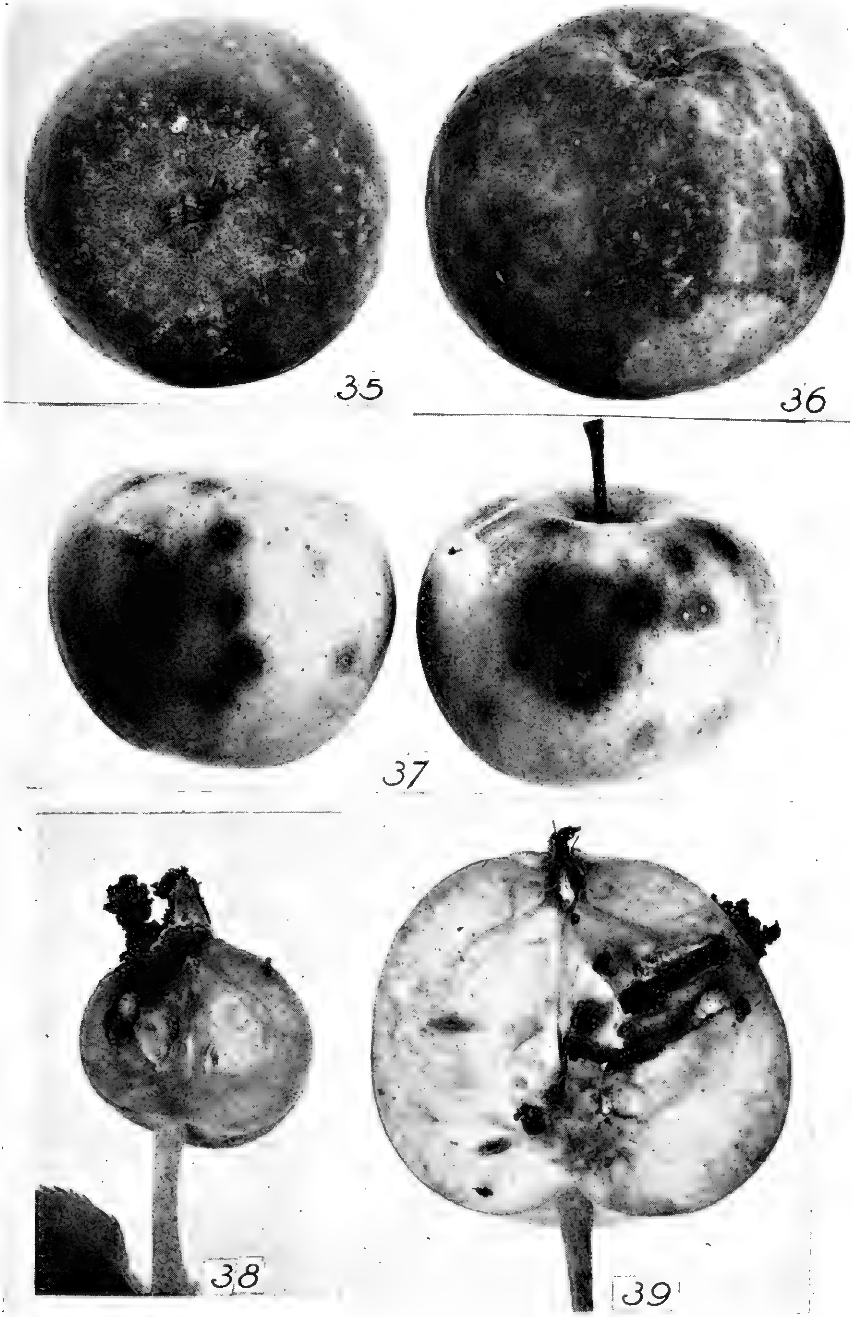
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Plate XIII

INJURIES PRODUCED BY CARPOCAPSA POMONELLA

40, Apples spread apart to show the work of codling-moth larvae where the fruits rested in contact. Photographed on July 28

41, Fall Pippin apple showing the work of second-brood larvae during September. Each white frothy spot indicates where a larva was trying to enter the fruit. Photographed on September 18

42, Slices from apples that show "side-worm" injury produced by late-appearing larvae of the first brood. The larvae were poisoned, but did not die before making a small hole in the fruit. Color develops around the spots much as it does around scale insects. Photographed on August 4

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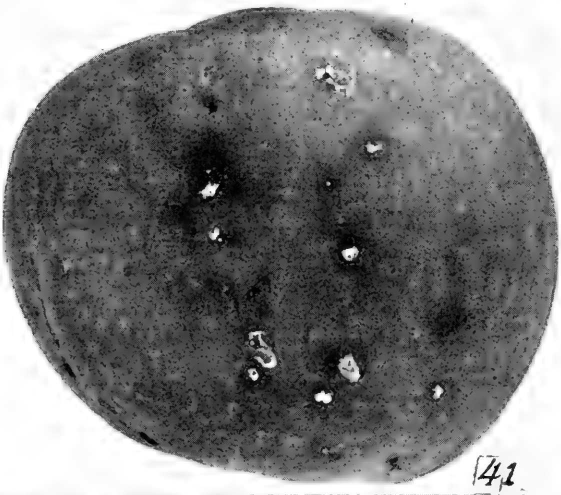

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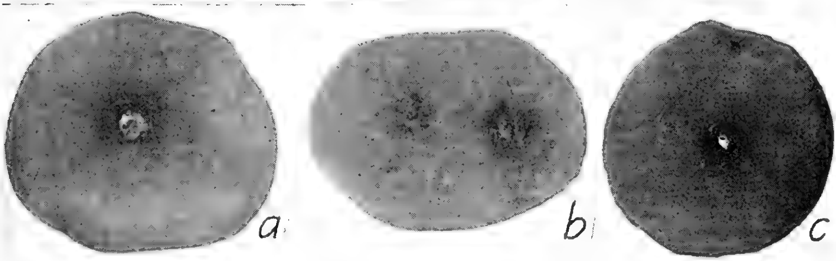

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Plate XIV

INJURIES PRODUCED BY CARPOCAPSA POMONELLA AND BY ENARMONIA PRUNIVORA

43, Rhode Island *Greening* apple showing two larval exit holes, indicating that two codling-moth larvae had developed in the fruit. Photographed on September 26

44, The apple shown in figure 43, in section, exhibiting the two larval burrows. Brown rot may be seen developing along the right-hand burrow

45, Baldwin apple showing the work of Pollenia and other muscid flies, which frequently enlarge the "side-worm" holes made by codling-moth larvae. Photographed on September 3

46, Baldwin apple showing the white frothy spot where a late-appearing codling-moth larva of the first brood entered into the scar cavity made by a leaf-roller larva. Photographed on July 20

47, Slices from apples showing "side-worm" injuries produced by second-brood codling-moth larvae in September. The larvae were dead except in the left-hand slice, which shows a white exudation from the spot. Photographed on September 9

48, Sections of apple showing (at right) the surface work of the larva of *Enarmonia prunivora* in an apple, and (at left) the tunnels just beneath leading to the core. Photographed on September 9

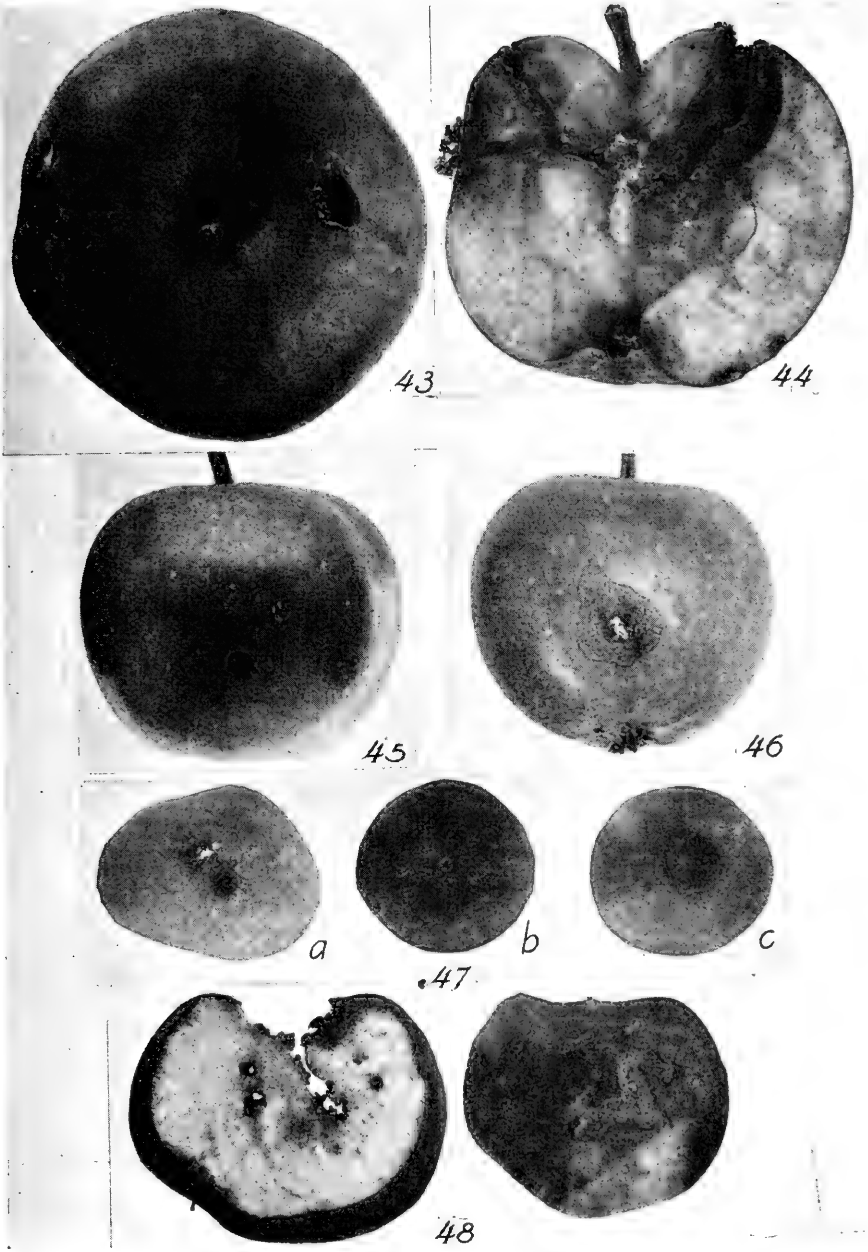
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Plate XV

INJURIES PRODUCED BY ARCHIPS ARGYROSPILA

49, Work of a leaf-roller larva in destroying a fruit cluster, showing how the leaves and the young fruits are webbed together. Photographed on June 9

50, A leaf-roller larva protruding from its rolled leaf retreat, and the apple next to it on which the larva fed. Photographed on June 9

51, Rhode Island *Greening* apples showing types of fresh scars made by leaf-roller larvae. Photographed on June 24

52, Additional fruits that show typical leaf-roller scars found on June 24

53, Pippin apples showing deep and narrow scars. These fruits had part of their cores eaten out, but were able to recover and grow to maturity. Photographed on September 19

54, Twenty Ounce apples that show deep cavities made by feeding larvae. Two of these apples were recovering, while the specimen in the center had succumbed to the injuries received. Photographed on July 8

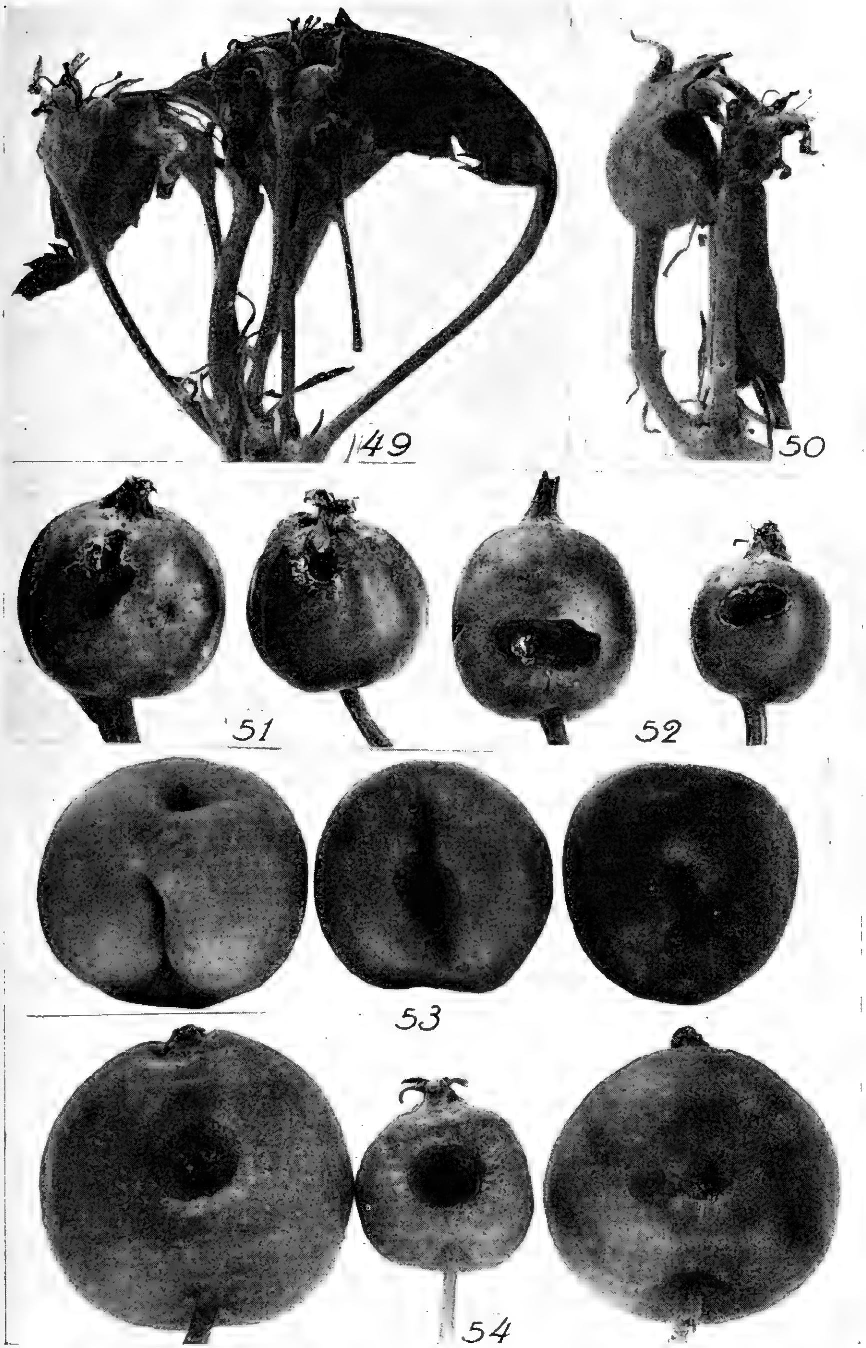
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Plate XVI

INJURIES PRODUCED BY ARCHIPS ARGYROSPILA AND BY XYLINA ANTENNATA

55, Apples showing scars made by leaf-roller larvae. Photographed on July 7

56, Apples showing scars made by *Xylina antennata*, to be compared with the work of the leaf-roller larvae shown in figure 55. Photographed on July 7

57, Baldwin apples exhibiting deep scars made by leaf-roller larvae. Photographed on August 30

58, Twenty Ounce apple showing how the deep cavity made by a leaf roller has grown out and nearly filled the original cavity. Photographed on October 21

59, Roxbury apple showing a small, shallow scar made by the late feeding of a leaf-roller larva. The large crack which encircles the apple was caused by growth pressure after the skin of the fruit had become hardened

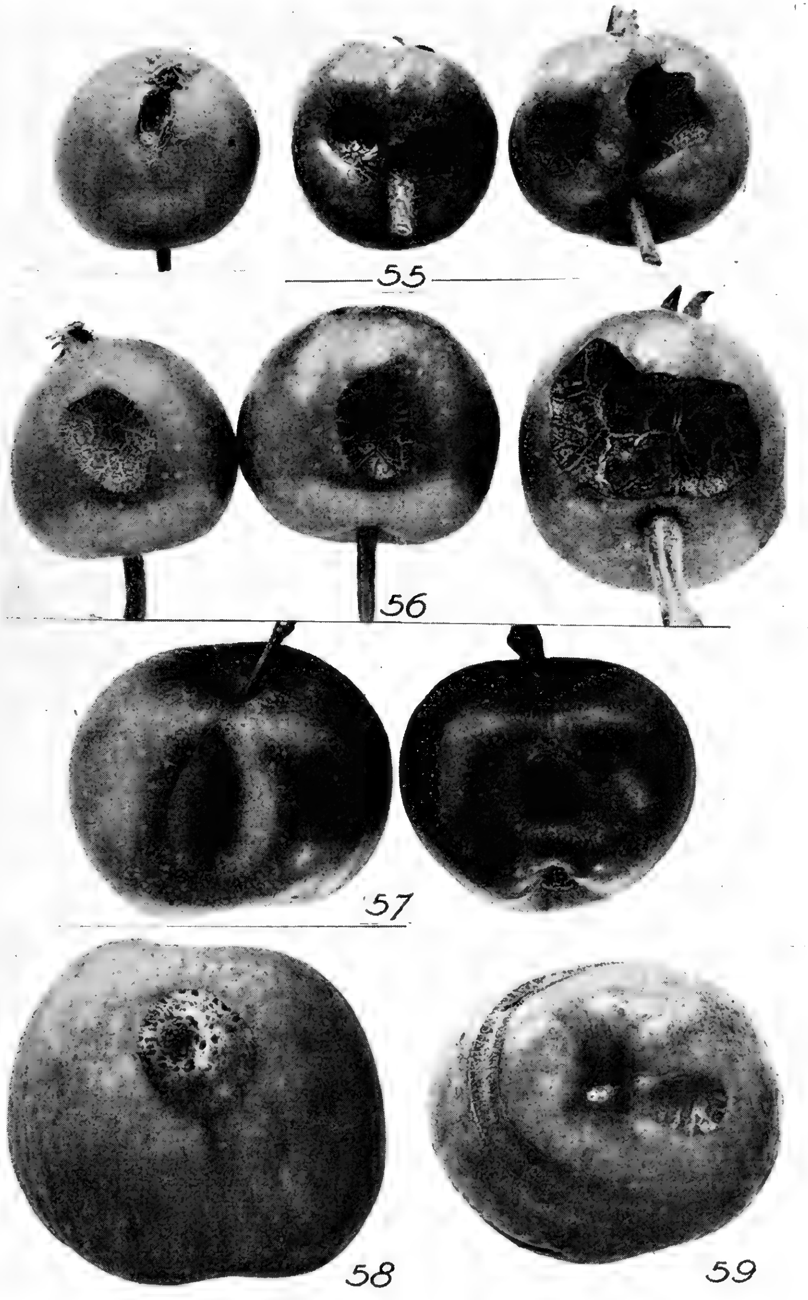
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Plate XVII

INJURIES PRODUCED BY XYLINA ANTENNATA

60, Comparison between the injury made by a leaf-roller larva (left) and the feeding work on young apples of a green fruit worm (right). Photographed on June 12

61, Nearly full-grown larva of *Xylina antennata,* feeding, with its head in a young apple. Photographed on June 12

62, Scars made by a fruit worm on June 20, photographed on June 24 after the wounds have turned brown. These fruits have just attained the size which would enable them to recover from shallow wounds such as are shown

63, Apples showing scars made by fruit worms on June 18, photographed on June 24 when the scar tissue was just beginning to form

64, Apples photographed on June 24, showing scars produced by young fruit-worm larvae about June 8 to June 10. The scars were so small that the fruits were recovering

65, Bartlett pears showing mature scars caused by the feeding of one fruit-worm larva in June. Photographed on September 9

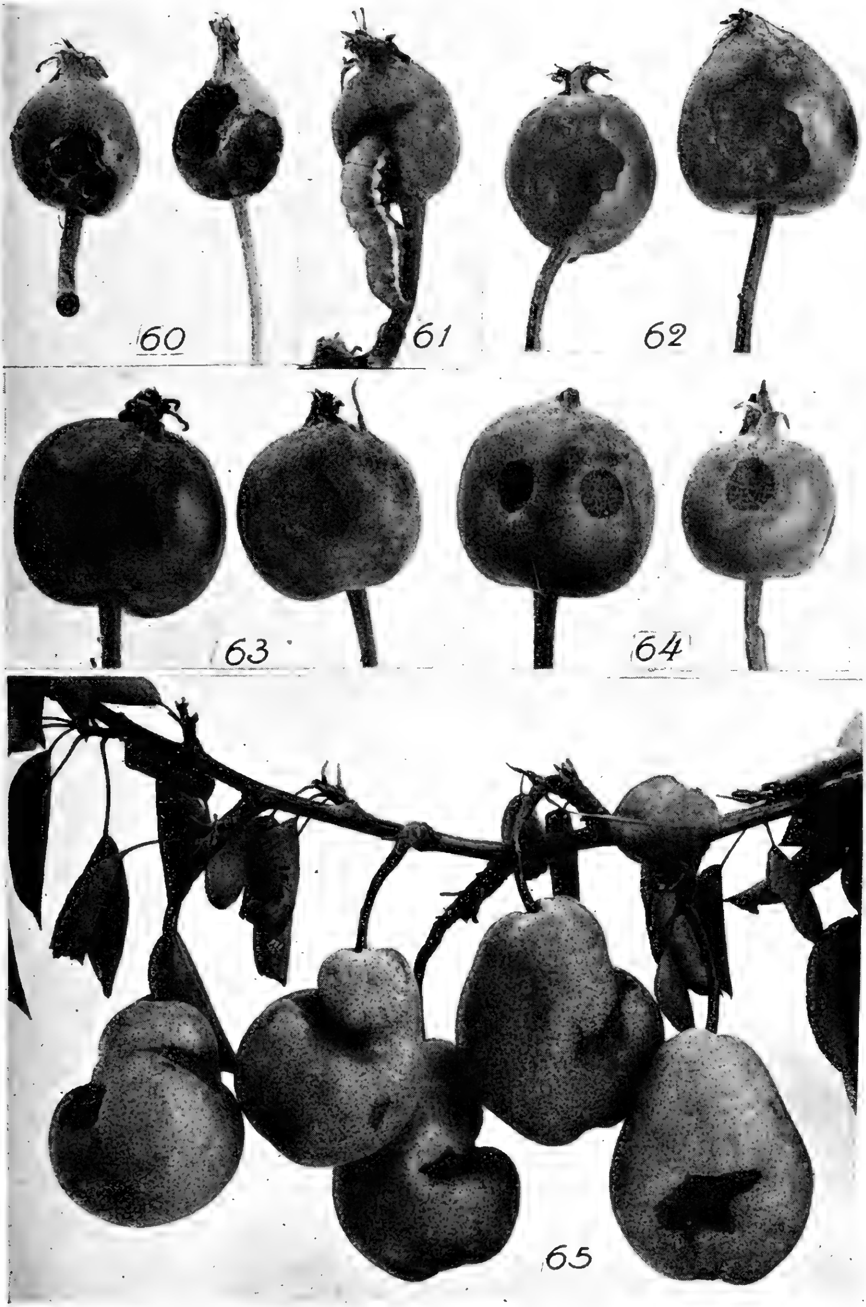
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Plate XVIII

INJURIES PRODUCED BY XYLINA ANTENNATA

66, Rhode Island *Greening* apple showing mature scars produced by the intermittent feeding of fruit-worm larvae at a time when the fruit was not more than half an inch in diameter. Photographed on August 14

67, Pippin apple showing excessive injury by a fruit-worm larva, the apple, however, continuing to grow. Photographed on November 1

68, Baldwin apple, natural size, showing that the core was reached by a feeding fruit-worm larva, and yet the fruit recovered and grew to maturity. Photographed on November 1

69, Tompkins King apple showing a large fruit-worm scar, this case being unusual in that two scars joined to form one large irregular one. Photographed on September 9

70, Baldwin apples showing typical broad fruit-worm scars. Photographed on August 23

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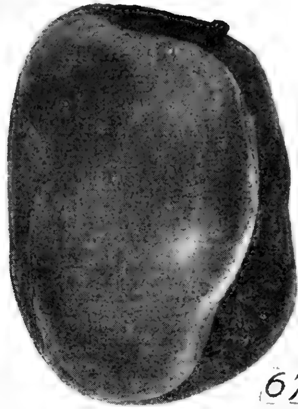

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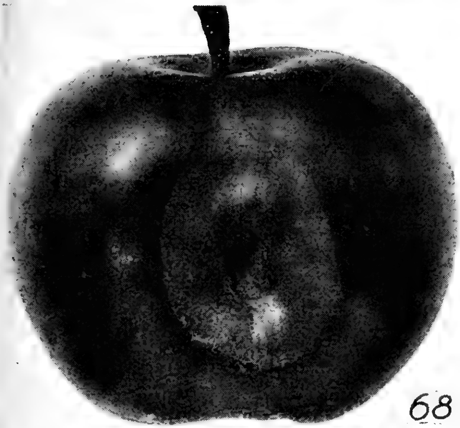

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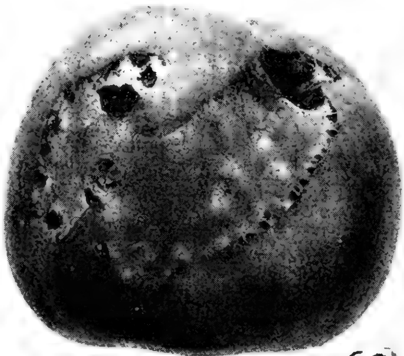

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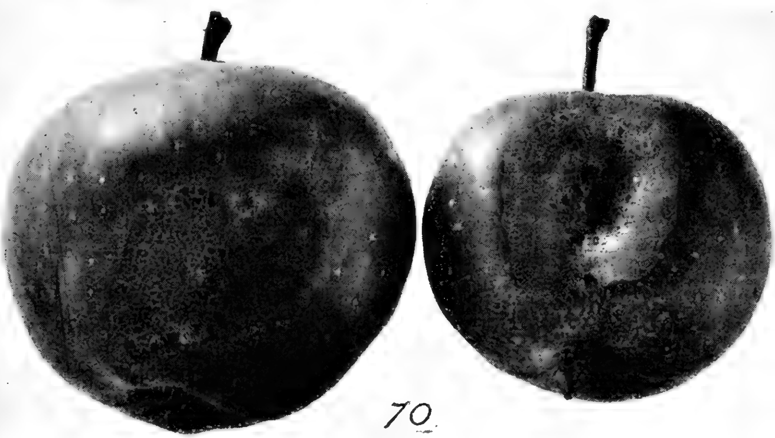

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Plate XIX

INJURIES PRODUCED BY XYLINA LATICINEREA, RHYNCHAGROTIS PLACIDA, AND HEMEROCAMPA LEUCOSTIGMA

71, A larva of *Xylina laticinerea,* nearly full-grown, and four young apples on which it had been feeding. Photographed on June 18

72, Rhode Island *Greening* apple on which a larva of *Rhynchagrotis placida* fed from June 16 to June 19. Picked and photographed on August 16

73, Baldwin apple showing mature scars produced by a larva of *Rhynchagrotis placida* feeding on the young fruit in June. Photographed on September 21

74, Rhode Island *Greening* apples showing two tussock-moth larvae at work, and the typical scars, on June 24. The small apple at the right had received excessive injury, which would result in its early dropping

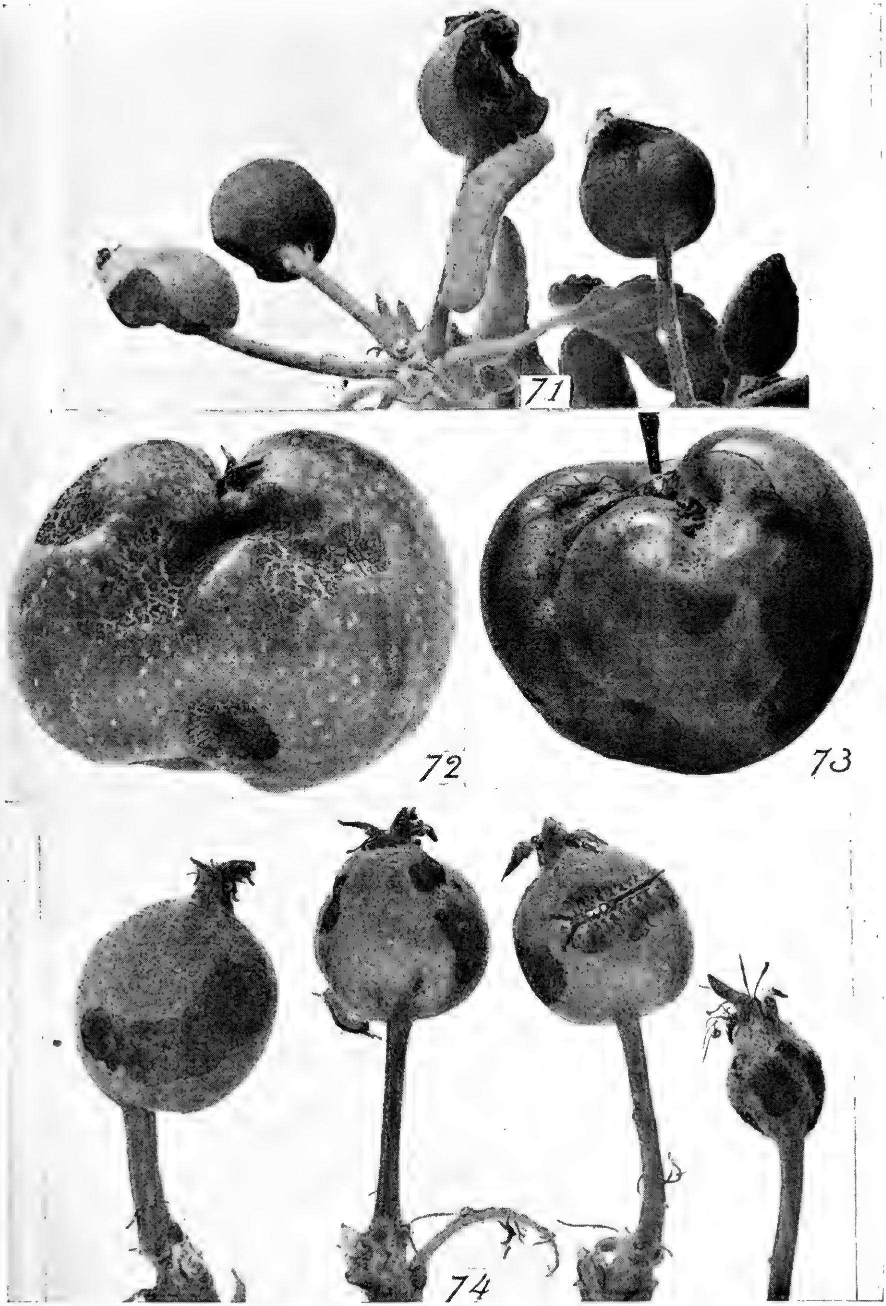
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Plate XX

INJURIES PRODUCED BY HEMEROCAMPA LEUCOSTIGMA

75, Work of one tussock-moth larva on a Rhode Island *Greening* apple. The larva was found at work on the apple on June 29, and it continued to feed until it was photographed on July 3

76, Baldwin apples which were recovering from injury, each apple showing several of the small, shallow scars that are characteristic of tussock-moth work. Photographed on July 4

77, Twenty Ounce apple showing the typical scars that result from tussock-moth work. Photographed on August 30

78, Rhode Island *Greening* apple showing the large, shallow scars, with irregular margins, characteristic of large scars made by the tussock-moth larva. Photographed on September 22

79, Northern Spy apples showing the long, slender feeding channels of the larva, this being a characteristic injury after the skin of the fruit has become hardened. Photographed on July 20

80, Twenty Ounce apple showing a scar that did not heal perfectly, due to the fact that the injury was received after active growth had stopped. Photographed on August 30

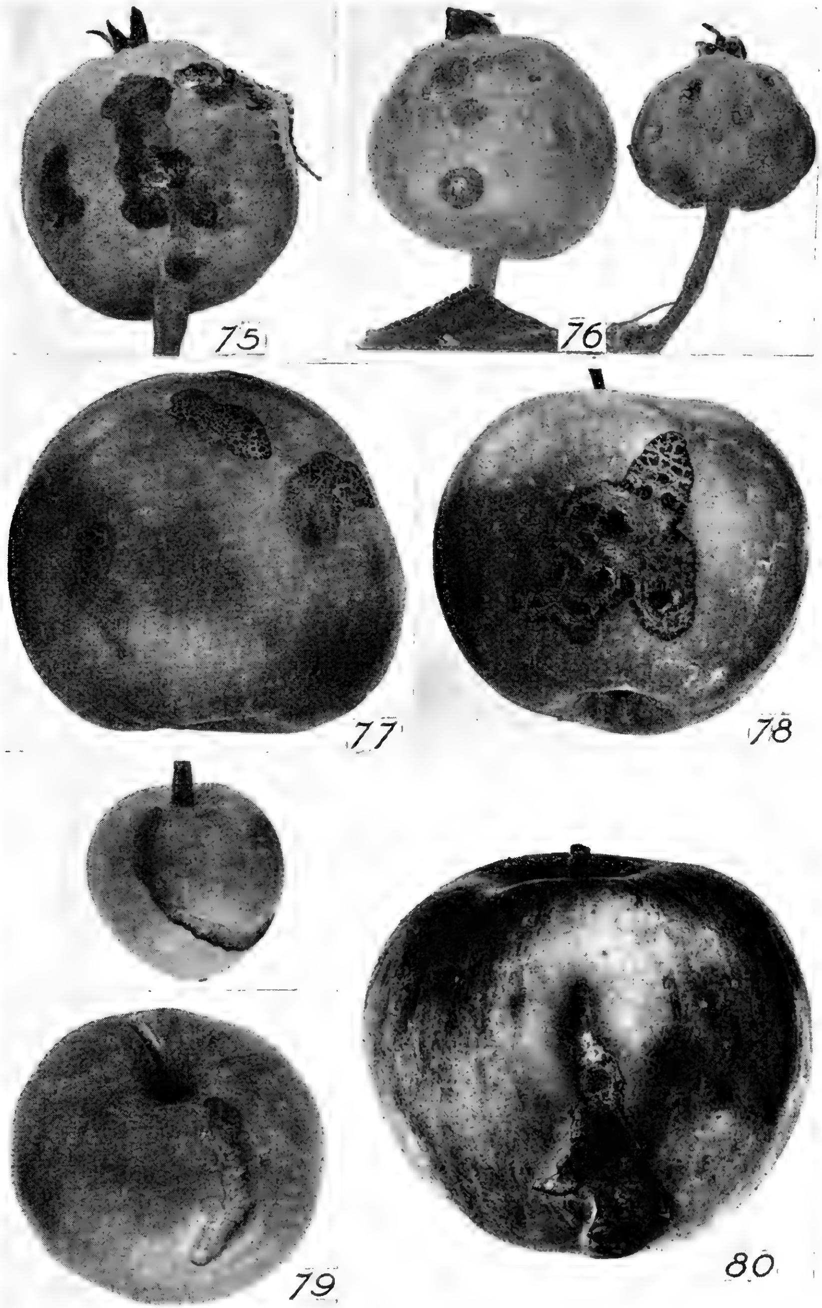
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Plate XXI

INJURIES PRODUCED BY HEMEROCAMPA LEUCOSTIGMA AND BY YPSOLOPHUS LIGULELLUS

81, Rhode Island *Greening* apple showing a very large and unusual tussock-moth scar, the wound having occurred in mid-July at a time when growth was so slow that brown rot might well have resulted. Photographed on October 21

82, Late tussock-moth work showing excessive feeding on one apple, the injury having occurred in July after the period when the apple was able to heal perfect scars. Photographed on December 18

83, Jonathan apple with tussock-moth scar, showing warting in the mature scar. Photographed on October 31

84, Apple showing a tussock-moth scar (below), and warting produced on a scab spot (above). Photographed on September 1

85, Baldwin apples showing palmer-worm work. The larva that caused the injury may be seen protruding its head from a webbed retreat. Photographed on June 25

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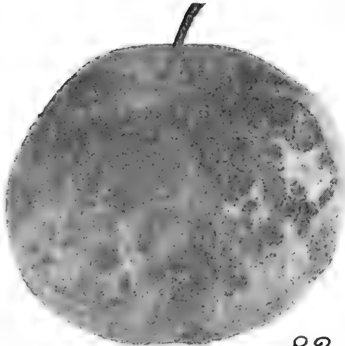

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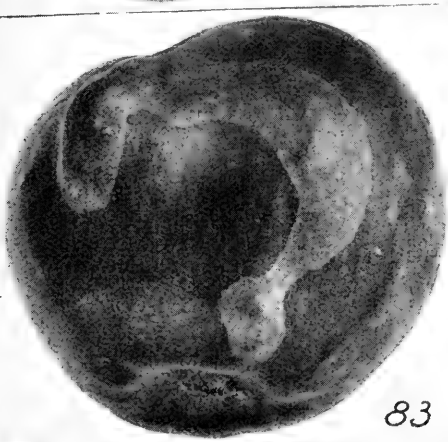

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Plate XXII

INJURIES PRODUCED BY YPSOLOPHUS LIGULELLUS AND BY TMETOCERA OCELLANA

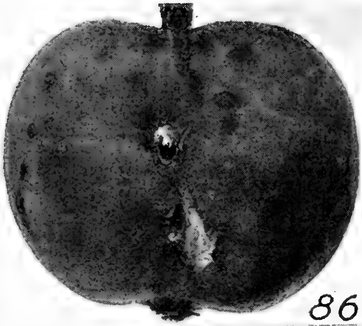
86, Roxbury apple with two small holes made by a palmer worm, showing also some of the web which the larva invariably spins about the cavities it makes. Photographed on July 27

87, Roxbury apple with five small holes made by one palmer worm. The crack showing at either side is the result of growth after the skin of the apple had become hardened. Photographed on July 21

88, Roxbury apples showing scars produced by late feeding of the palmer worm. The apple on the right shows a large and imperfectly healed scar, while the one on the left has a deep cavity where a larva fed for a short time just prior to pupation. Photographed on August 12

89, Pound Sweet apple showing the work of a bud-moth larva just beneath a leaf that was webbed to the side of the fruit. Photographed on September 15

90, A slice from an apple showing where a bud-moth larva had drawn a leaf against the fruit and fed for a short time. Photographed on August 8



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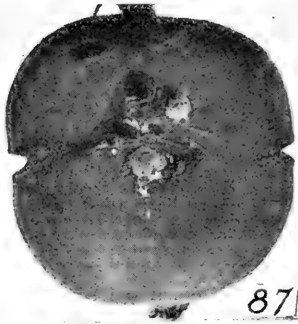

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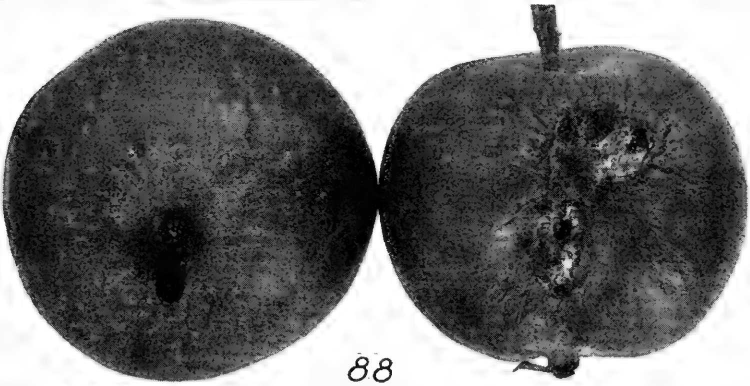

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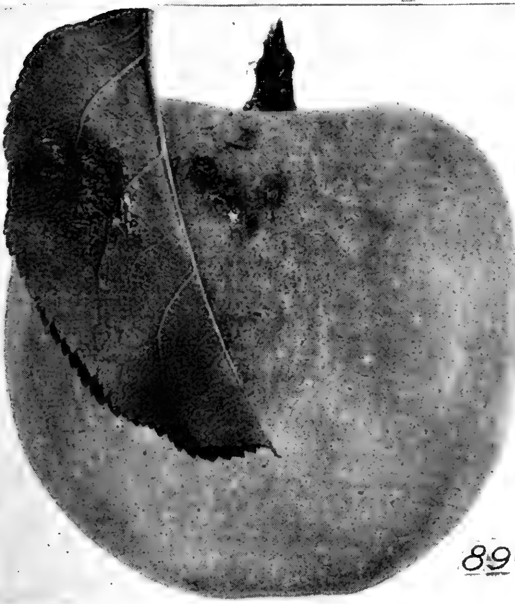

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Plate XXIII

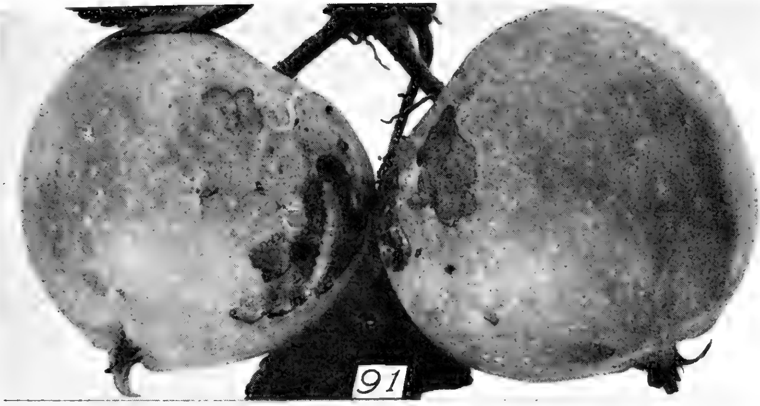
INJURIES PRODUCED BY EULIA VELUTINANA

91, The leaf-roller larva and its work between two Genesee Flower apples. Photographed on July 28

92, The moth spread, enlarged about four times

93, Rhode Island *Greening* apple showing the work of a larva. Photographed on September 21

94, Baldwin apple showing the typical shallow, late-feeding work of the larva, in which little more than the skin of the fruit is eaten. Photographed on September 25



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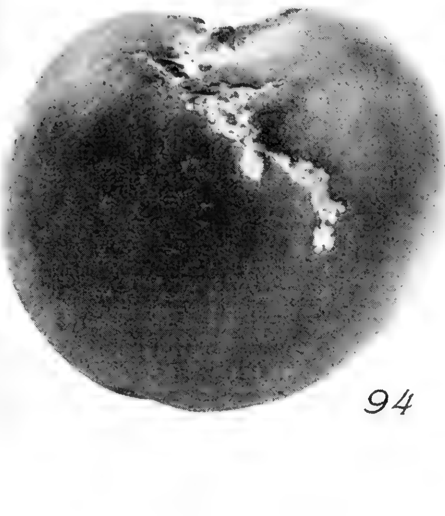

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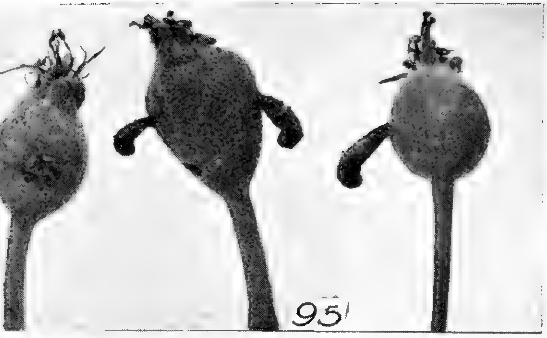
Plate XXIV

INJURIES PRODUCED BY COLEOPHORA MALIVORELLA

95, Case-bearers at work on young apples, showing the small round holes that the larvae make in the fruit. Photographed on June 9

96, Twenty Ounce apples exhibiting typical work of the larvae. Some of the larger scars show a small, funnel-shaped depression at the center, indicating that growth had not completely filled the feeding cavity. Photographed on August 30

97, Twenty Ounce apple showing the life work of one larva. The larger scars were made while the apple was growing rapidly, while the smaller scars were made toward the end of the larval feeding period. The "pistol case" may be seen on the twig to which the larva moved for pupation. Photographed on August 30



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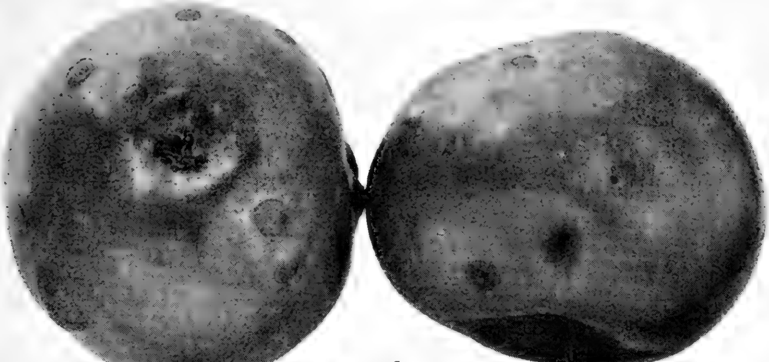

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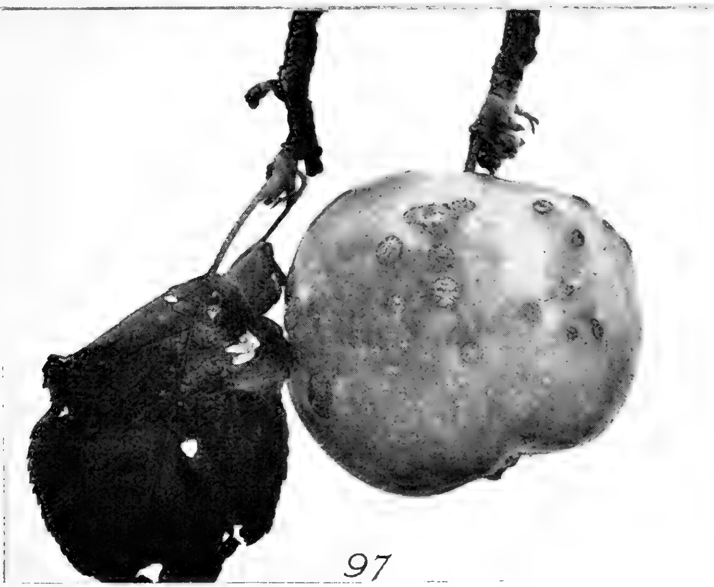

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Plate XXV

INJURIES PRODUCED BY COLEOPHORA MALIVORELLA AND BY COLEOPHORA FLETCHERELLA

98, Mature scars on Detroit Red apple caused by *Coleophora malivorella,* showing that a splitting and enlargement of the wound has taken place around certain scars. Photographed on October 2

99, Work of *Coleophora malivorella* on a crab apple, showing that some warting occurred on the scars. Photographed on September 27

100, Slices from Baldwin and Twenty Ounce apples which exhibit all types of scars caused by *Coleophora malivorella.*. Photographed on September 3

101, *Coleophora fletcherella,* showing the case-bearers at work and the feeding punctures they make. Slightly enlarged. Photographed on May 29

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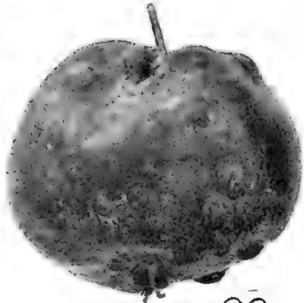

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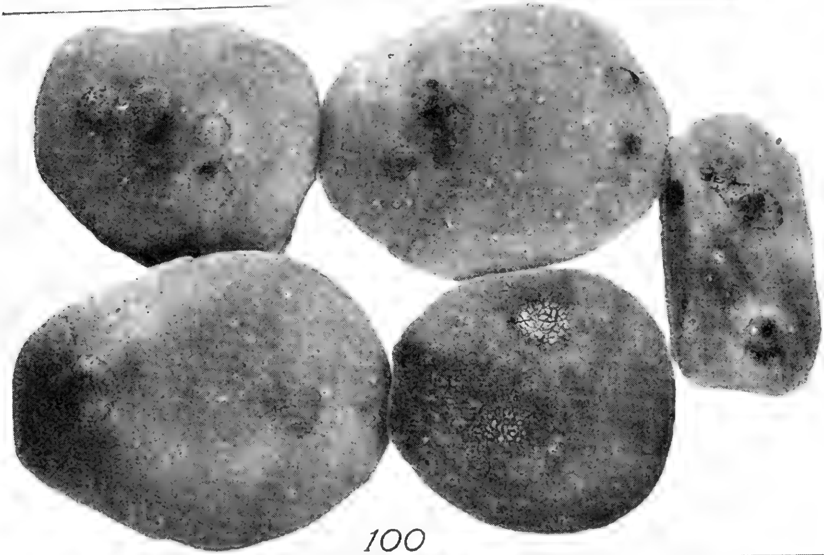

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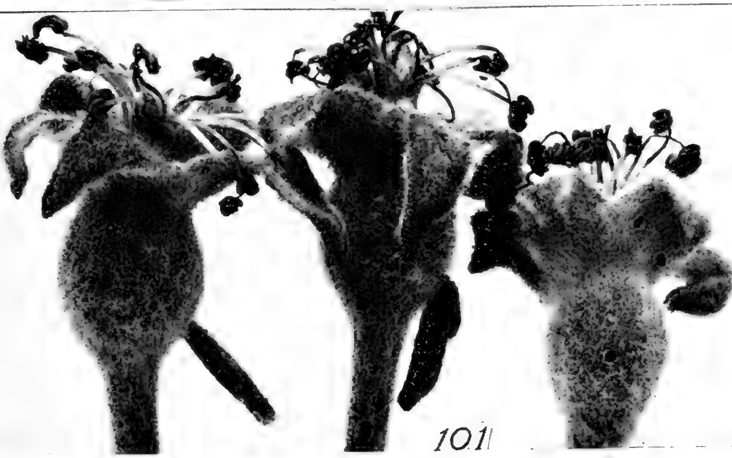

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Plate XXVI

INJURIES PRODUCED BY HYPHANTRIA TEXTOR

102, Alexander apple showing the work of webworms on the fruit, with web and excrement clinging to it. Photographed on July 29

103, Yellow Transparent apple which was fed upon by webworms with the result that it shriveled and dried up. Photographed on August 2

104, Alexander apples on a limb that was inclosed in a webworm nest. The work of the larvae may be seen on the apples. Photographed on July 28


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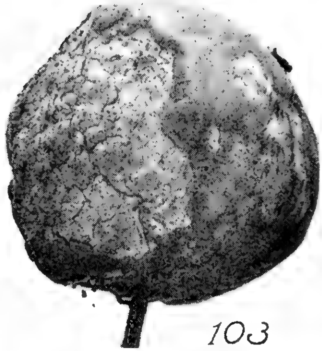
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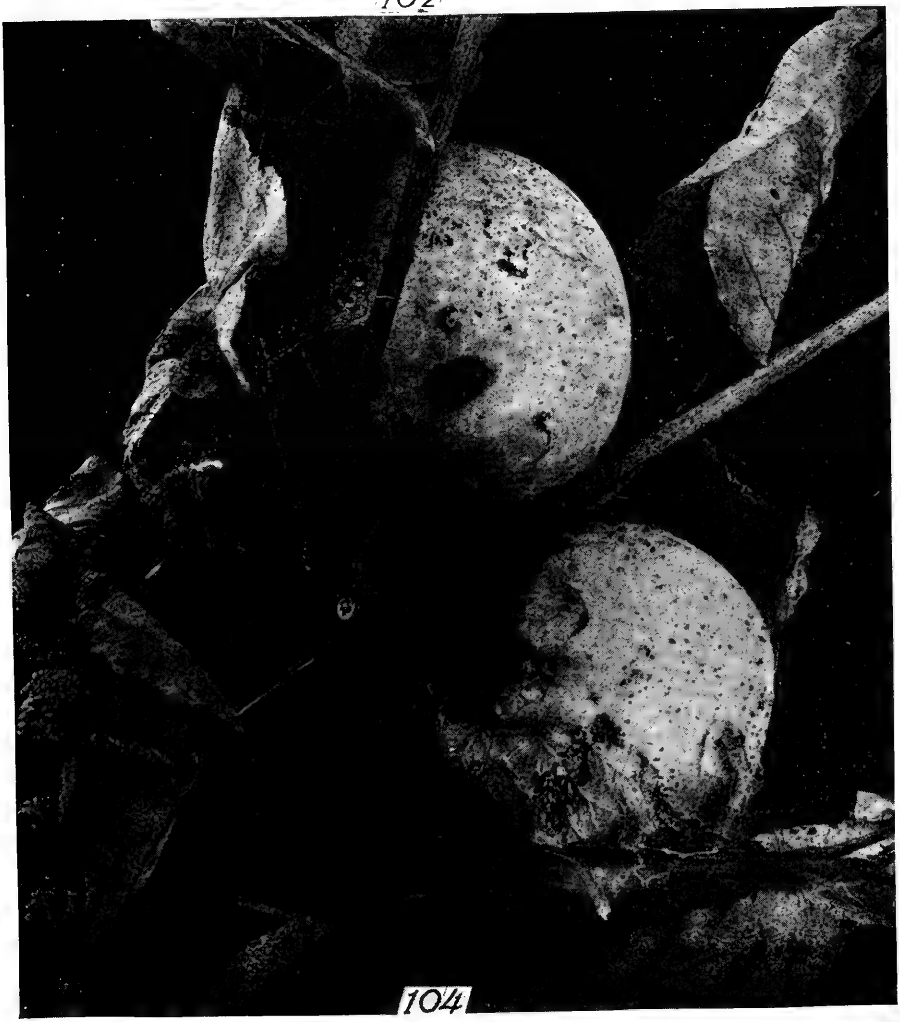
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Plate XXVII

INJURIES PRODUCED BY MARMARA POMONELLA AND BY CONOTRACHELUS NENUPHAR

105, Baldwin apple showing a serpentine mine in the skin of the fruit, produced by *Marmara pomonella*. Photographed on November 10

106, Baldwin apple showing a serpentine mine of *Marmara pomonella* which was more or less coiled and formed a blotch. Photographed on November 10

107, A *Conotrachelus nenuphar* curculio resting on a young apple beside a feeding puncture. Enlarged 2½ times. Photographed on May 29

108, A *Conotrachelus nenuphar* curculio resting on a young apple after having made a small feeding puncture, which may be seen just beneath. Enlarged 2½ times. Photographed on May 29

109, Two young apples showing crescents made by the female of *Conotrachelus nenuphar* when laying eggs, and one fruit (at right) showing a typical round feeding puncture. Enlarged 2 times. Photographed on May 29

110, A *Conotrachelus nenuphar* curculio making a feeding puncture in a large apple. Photographed on June 25

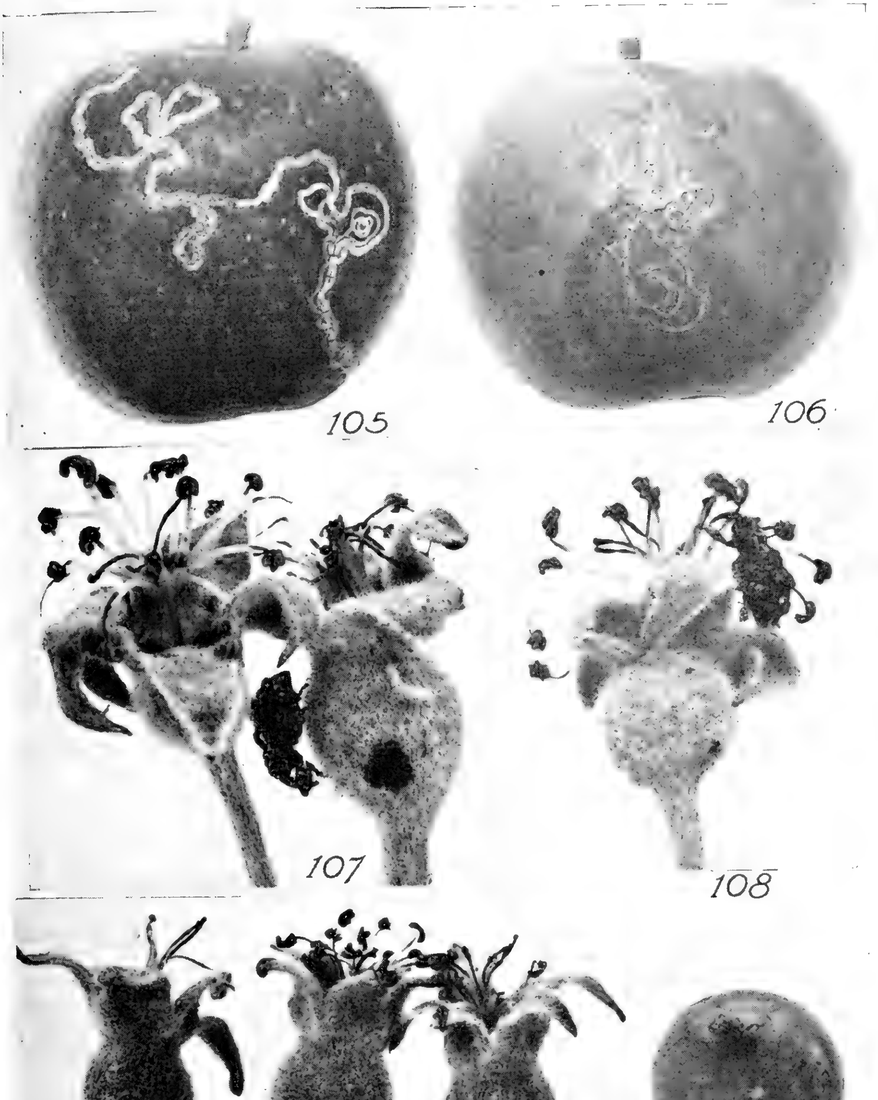
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Plate XXVIII

INJURIES PRODUCED BY CONOTRACHELUS NENUPHAR

111, Baldwin apples showing egg crescents made by curculios when feeding early in June. Two of the crescents show a white exudation issuing from the egg puncture, indicating that the young grubs are trying to feed. Photographed on June 18

112, Apple in section, showing the burrow of a curculio larva leading from the egg puncture toward the core. This fruit was picked from the tree just before the photograph was made, on July 13

113, Injuries on a Rhode Island *Greening* apple with which a female curculio was caged from June 29 to July 6. Photographed on July 21

114, Twenty Ounce apple showing several egg-crescent scars. Some of these resemble case-bearer work, but the egg-puncture mark which is discernible on all but one scar indicates that the plum curculio made the wounds. Photographed on September 9

115, Red Astrachan apple showing both the crescents made by the plum curculio, and the irregular, splitting scars resulting from punctures of *Lygidea mendax*. Photographed on July 8

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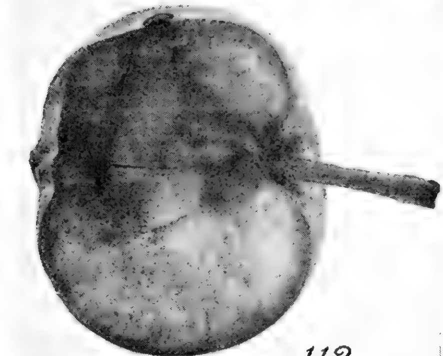

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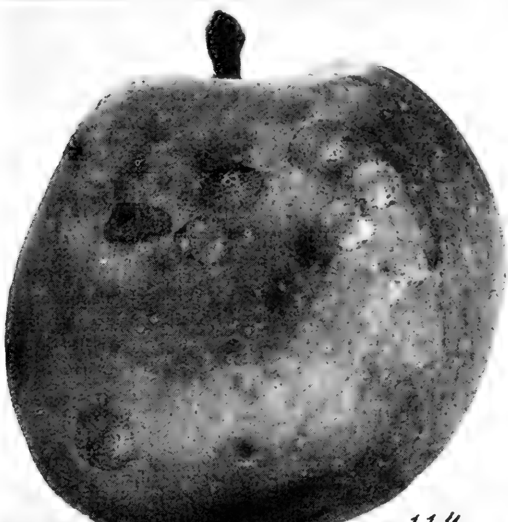

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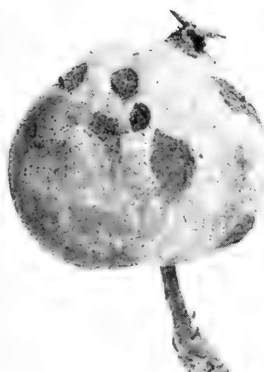

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Plate XXIX

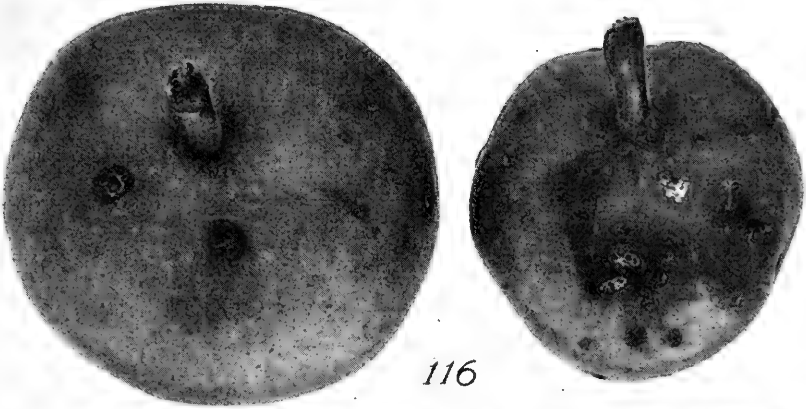
INJURIES PRODUCED BY CONOTRACHELUS NENUPHAR

116, Curculio injury on two Roxbury apples, produced during the last few days of July and the first week of August. The fruits show feeding punctures as well as egg crescents. Several of the punctures are surrounded with brown rot. Photographed on August 8

117, Slices from apples showing egg-crescent scars which are perfectly formed but some of which are much less distinct than are others. Photographed on November 29

118, Northern Spy apple showing the irregular scars produced by *Lygidea mendax*, which may be distinguished from the scars with uniform margins that usually result from curculio punctures. Photographed on September 15

119, Jonathan apple showing curculio scars bulging out or warting beyond the normal surface of the fruit. Photographed on October 31



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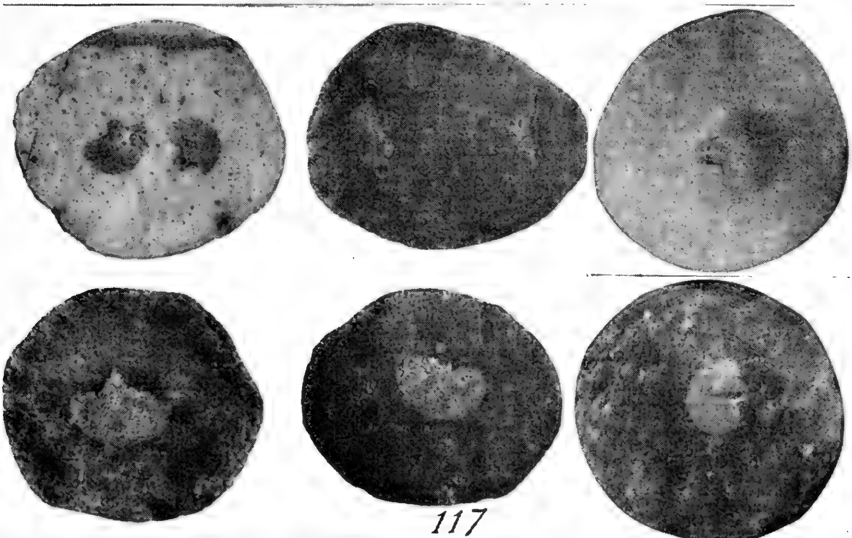

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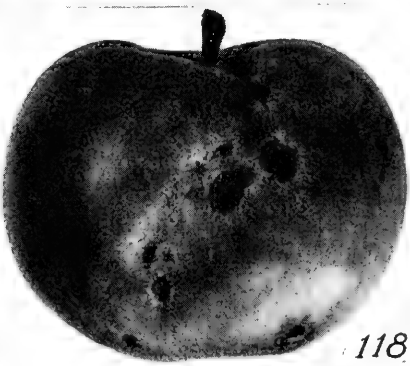

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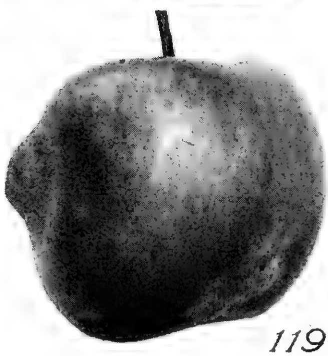

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Plate XXX

INJURIES PRODUCED BY CONOTRACHELUS NENUPHAR AND BY ANTHONOMUS QUADRIGIBBUS

120, Rhode Island *Greening* apple on which curculio scars were enlarged by muscid flies, the flies feeding on the brown rot as it formed in the wounds. Photographed on August 22

121, Rhode Island *Greening* apple (at left) and Maiden Blush apple (at right) cut in section to show the extent of the cavities formed where flies had enlarged the wounds made by *Conotrachelus nenuphar*. Photographed on August 22

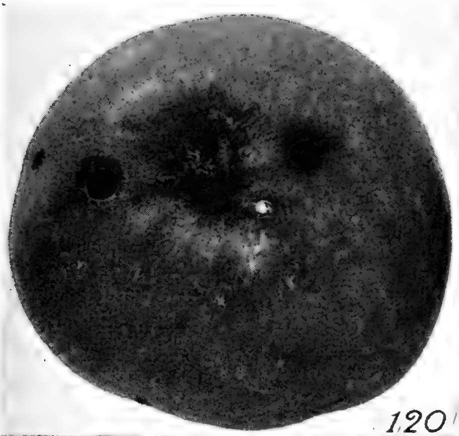
122, An *Anthonomus quadrigibbus* curculio on the side of a young apple. Enlarged 2½ times. Photographed on May 29

123, A female of *Anthonomus quadrigibbus* ovipositing in a young apple while a second beetle rests on the calyx above. Photographed on May 28

124, Two *Anthonomus quadrigibbus* curculios resting on a young apple after one has laid an egg. Photographed on May 28

125, Baldwin fruits which were so severely injured by *Anthonomus quadrigibbus* between June 25 and June 30 that they dropped. Photographed on July 7

126, Baldwin apple cut in section to show the egg and feeding cavities made by *Anthonomus quadrigibbus*. Photographed on July 5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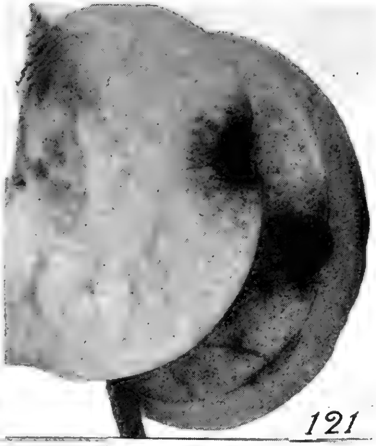
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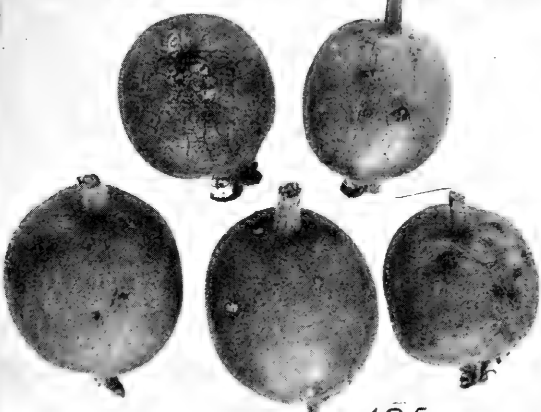
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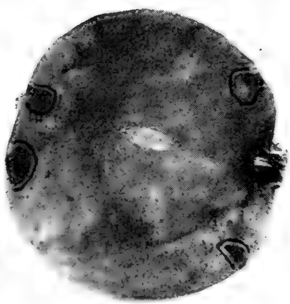
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Plate XXXI

INJURIES PRODUCED BY ANTHONOMUS QUADRIGIBBUS

127, Baldwin apples showing the scars produced by a pair of curculios which were caged on the fruit from June 16 to July 6. Natural size. Photographed on October 21

128, Stark apples which recovered from egg punctures made by an apple curculio near the end of June. Photographed on September 5

129, Bartlett pears showing the egg and feeding punctures produced by a pair of apple curculios in the first week of July. The punctures all became filled with a hard, granular substance during subsequent growth. Photographed on September 9

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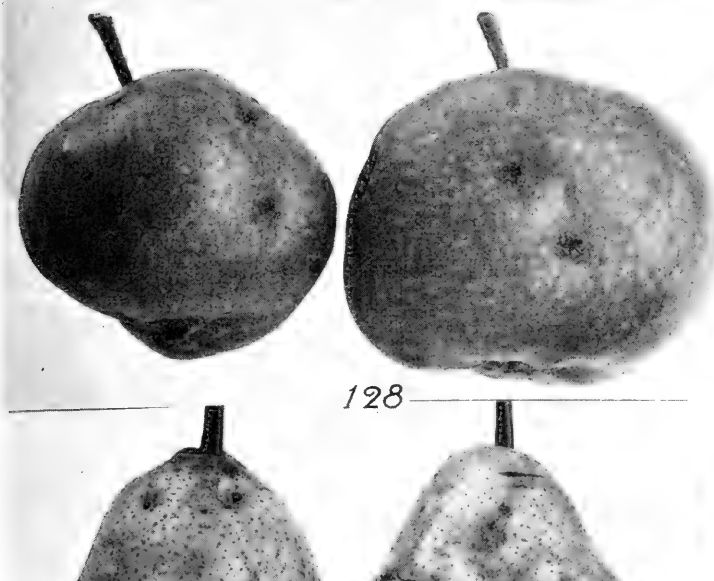

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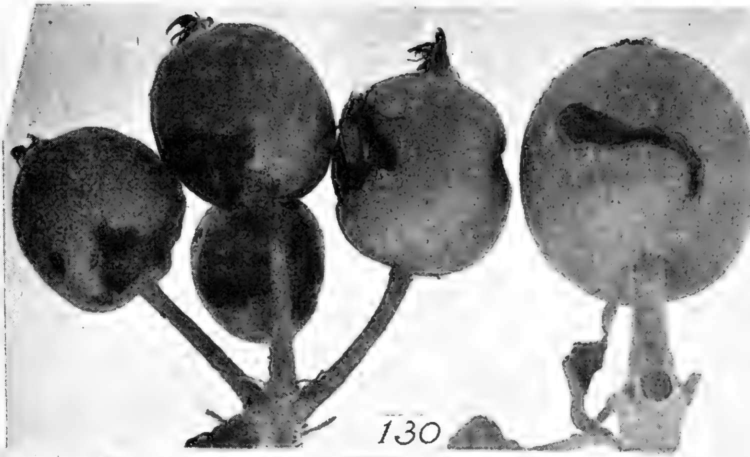
Plate XXXII

INJURIES PRODUCED BY MACRODACTYLUS SUBSPINOSUS

130, Baldwin apples showing the deep, irregular wounds produced by feeding rose chafers. Photographed on July 3

131, Baldwin and Tompkins King apples which show typical injuries caused by feeding rose chafers at the end of June. Photographed on July 3

132, Apples injured by rose chafers and found to have developed brown rot. All of these fruits shriveled and fell from the tree within two or three weeks after the injury occurred. Photographed on July 14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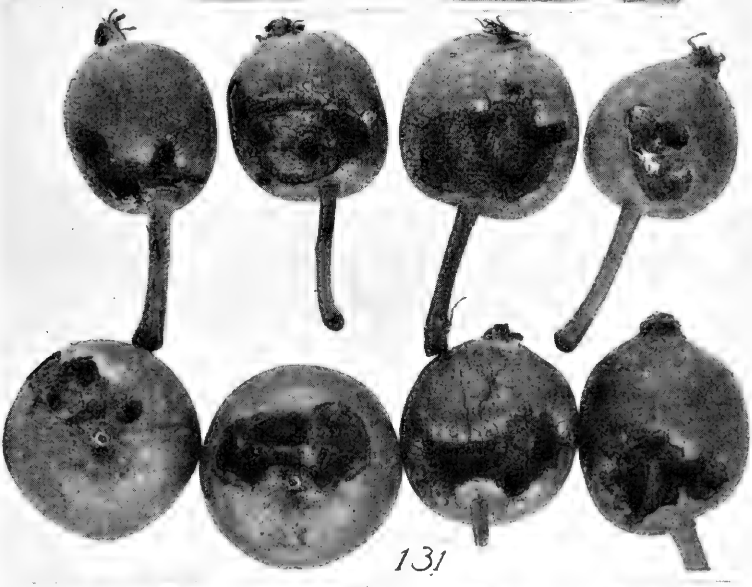
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Plate XXXIII

INJURIES PRODUCED BY RHAGOLETIS POMONELLA

133, A female apple-maggot fly in position for ovipositing in a crab apple. Photographed on September 5

134, Maiden Blush apple showing several oviposition marks. Photographed on August 23

135, Maiden Blush apple cut in section to show the work of the maggots within, also (at right) the emergence holes of the mature maggots. Photographed on September 5

136, Maiden Blush apple in section, showing two mature maggots in the brown-rot areas and also the tunnels made by other maggots in the flesh of the fruit. Photographed on October 31

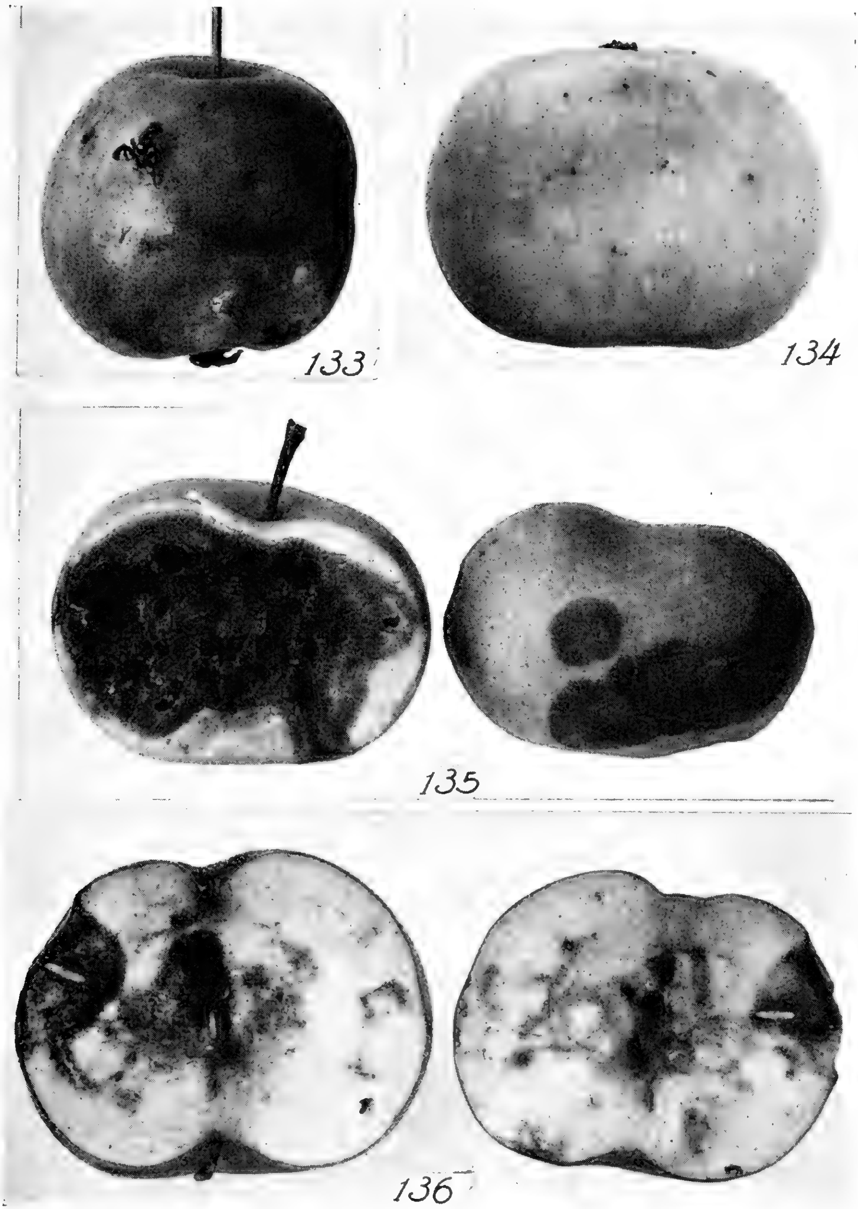
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Plate XXXIV

INJURIES PRODUCED BY RHAGOLETIS POMONELLA, THE BLACK ROT FUNGUS, AND SYNTOMASPIS DRUPARUM

137, Tompkins King apple showing the emergence holes of two apple maggots. One of these scars represents the extent to which brown rot developed during the four days following the exit of the maggot. Photographed on October 7

138, Crab apples showing the small dimples caused by the ovipositor of the chalcis fly, *Syntomaspis druparum*. Photographed on August 1

139, Tompkins King apple showing the emergence holes of apple maggots and the development of brown rot at the surface about the exit holes. Photographed on November 29

140, Baldwin apple showing numerous oviposition marks made by the apple-maggot fly. Each puncture appears somewhat enlarged and is surrounded by a dark green color, a condition caused by the black rot fungus (*Physalospora Cydoniae*) and the New England fruit spot (*Phoma pomi*), which were probably being introduced as an infection on the ovipositor of the fly. Photographed on October 28

141, Crab apples infested with the apple maggot. The lower apples show the dark tunnels of the maggots, which may be seen through the skin of the fruit. The apples in section show the extent of the tunnels and the development of brown rot. Photographed on September 21

142, Crab apples cut in section to show the dark trails left by the ovipositor of the female of *Syntomaspis druparum*. These scars may be seen leading from the surface of the fruit to the seeds. Photographed on August 1

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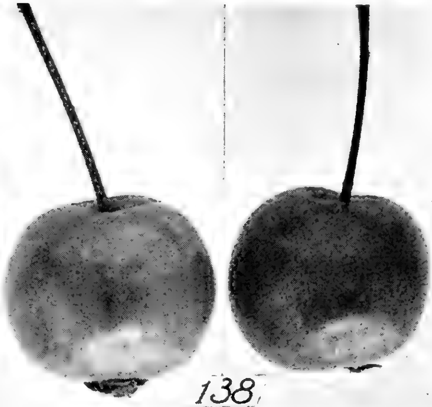

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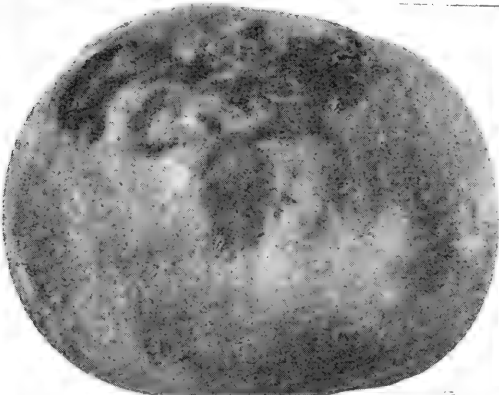

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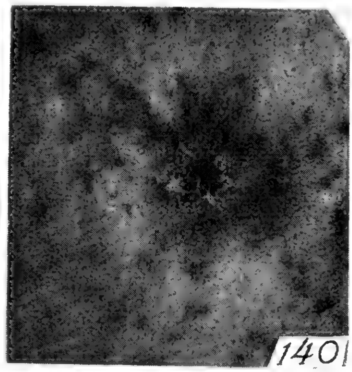

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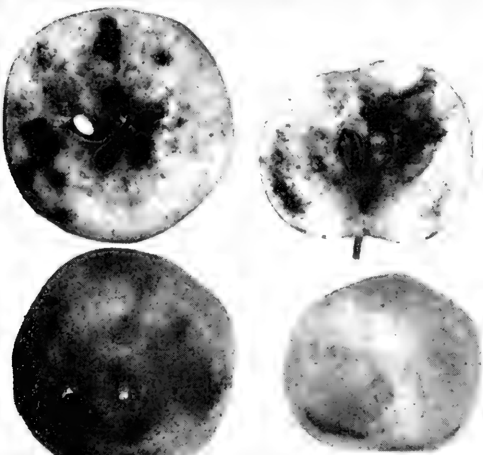

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Plate XXXV

AMETASTEGIA GLABRATA, AND THE WARTING OF SCARS CAUSED BY VARIOUS INSECTS

143, Section through an apple, showing the larva of *Ametastegia glabrata* in its hibernating cell. Photographed on October 28

144, Tolman apple with russet scars caused by *Lygidea mendax*, showing a slight warting of the scars. Photographed on September 18

145, Rhode Island *Greening* apples showing russet scars caused by *Lygidea mendax*. These apples underwent forced growth during August, causing a warting of the scars. Photographed on December 14

146, Ben Davis apples showing unusual warting of the scars made by tussock-moth larvae. Photographed on December 4

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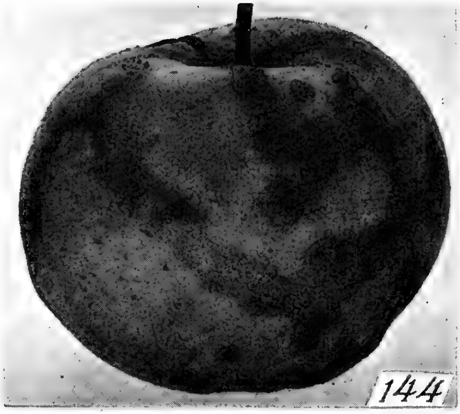

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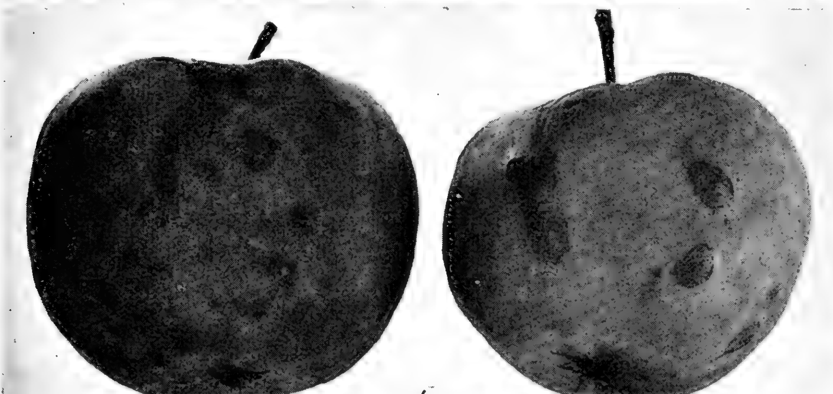

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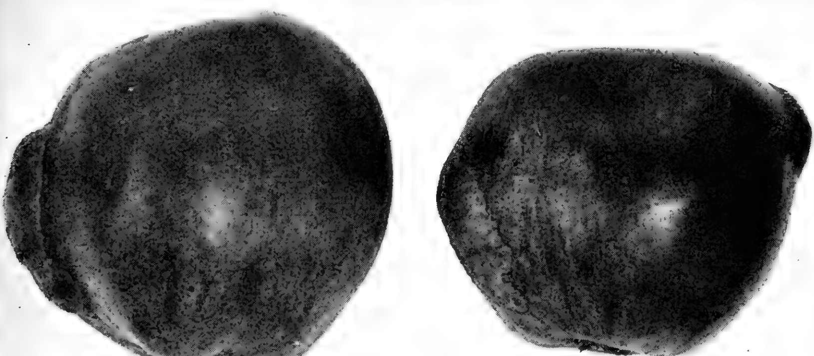

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Plate XXXVI

MECHANICAL INJURIES, PIN PUNCTURES, AND CRACKING FRUIT

147, Rhode Island *Greening* apple which was rubbed constantly by a limb just beneath, from the time it was an inch in diameter until picking time. Photographed on October 23

148, Baldwin apple which during its development was blown frequently against a sharp stub. Photographed on September 25

149, Rhode Island *Greening* apple which had small holes punched through the skin by a very sharp stub. Photographed on September 15

150, Baldwin apple showing the russet surface developed due to its rubbing against a stub from the time it was one-half inch in diameter until it had grown to be one and one-half inches in diameter, when the obstruction was removed. Photographed on October 23

151, Mature scars on a Rhode Island *Greening* apple, produced by puncturing the young fruit on June 25 with a No. 0 insect pin. Photographed on September 25

152, Roxbury apple showing large, deep cracks. Photographed on August 14

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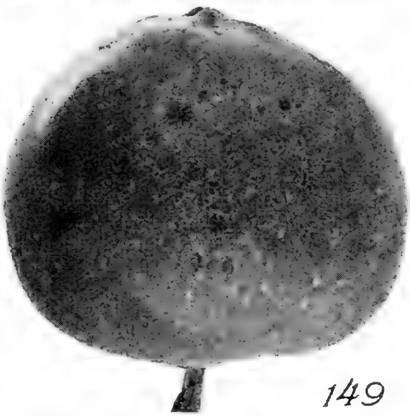

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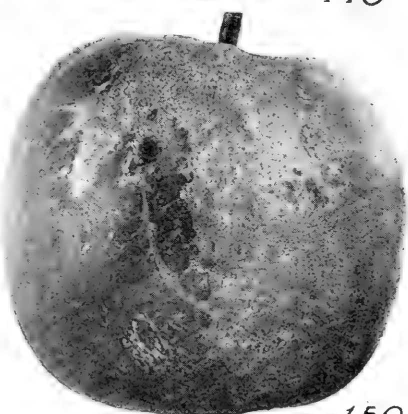

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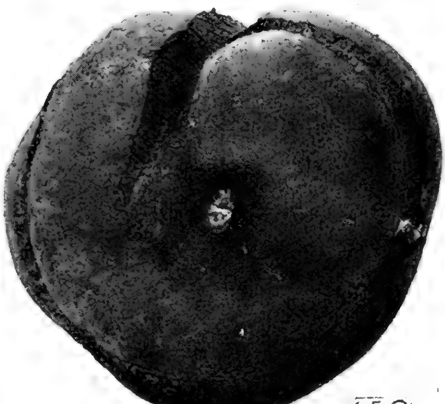

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Plate XXXVII

CRACKING FRUIT, AND LIME-SULFUR SPRAY INJURY

153, Roxbury apple completely circumscribed by a large crack. Photographed on July 21

154, Rhode Island *Greening* apples showing deep cracks which probably had their origin in the russet scars caused by redbugs. Photographed on August 17

155, Rhode Island *Greening* apple which developed large cracks over the surface, covered by the broad russet type of redbug scars. Photographed on August 30

156, Baldwin apple which was drenched with commercial lime-sulfur at the time of the calyx spray. Photographed on September 9

157, Apples from one limb of a Baldwin tree which always bore fruit having a russet skin and developing large, deep cracks. Photographed on August 22

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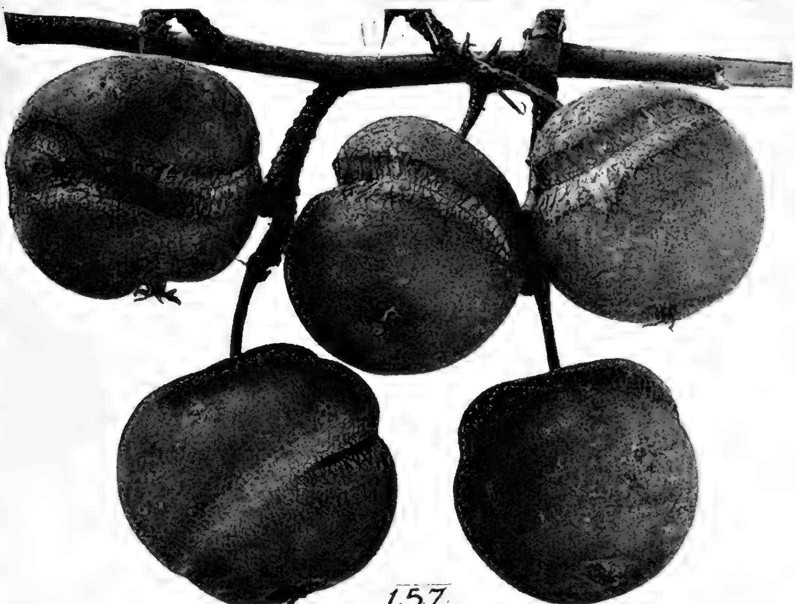

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Plate XXXVIII

LIME-SULFUR SPRAY INJURY, SUN-SCALD, AND FROST INJURY

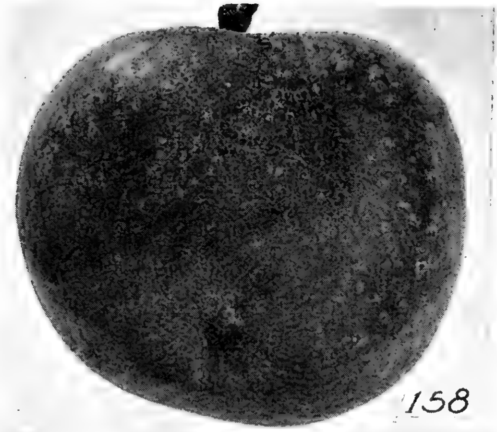
158, Tompkins King apple which was drenched with lime-sulfur spray (1 to 40) at the time of the calyx spray, that being the last time the tree was sprayed. Photographed on August 14

159, Sun-scald. Baldwin apple cut in section, the scalded tissue showing dark near the surface of the fruit. Photographed on August 16

160, Rhode Island *Greening* apples covered with spray material, which show dark on one side as a result of sun-scald. Photographed on August 16

161, Baldwin apple which developed sun-scald on August 5, as it appeared at picking time. The scalded tissue first turned brown, and then dried out and developed cracks as shown. Photographed on October 21

162, Young apples showing scars which gave the first signs of frost injury following the frost of May 28. Photographed on June 18



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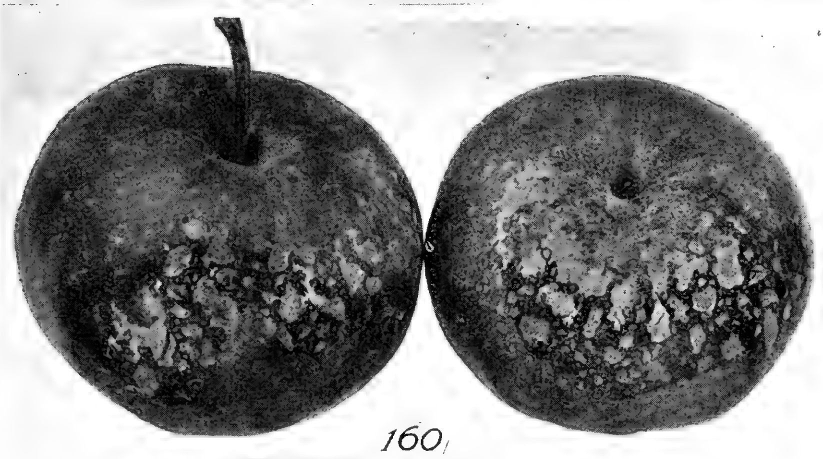

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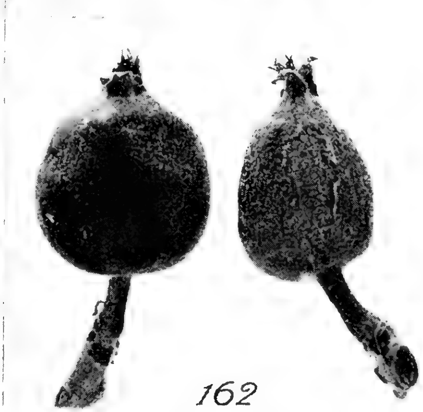

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Plate XXXIX

FROST INJURY

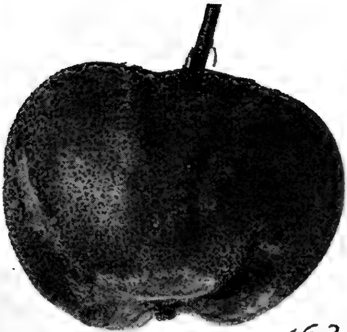
163, Northern Spy apple showing severe frost injury. This was picked in an orchard where nearly all of the fruit was killed by frost. Photographed on August 26

164, Genesee Flower apple showing a frost band about its circumference and one crack along the axis. Photographed on August 23

165, Large frost bands on two Genesee Flower apples. Photographed on August 17

166, Red Astrachan apples showing prominent frost bands. Photographed on August 21

167, Baldwin apples showing frost injury at the calyx end only. Photographed on August 1



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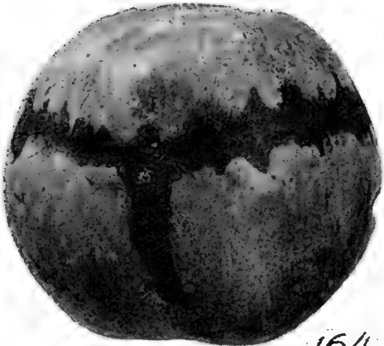

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Plate XL

FROST INJURY AND HAILSTONE INJURY

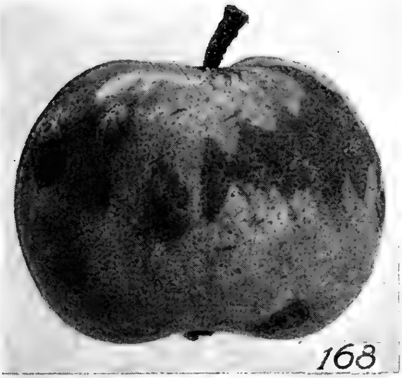
168, Maiden Blush apple showing the frost band broken into segments, also a slight warting of the scars. Photographed on September 7

169, Rhode Island *Greening* apple with scars that represent severe freezing of the young fruit. Photographed on September 9

170, Golden Russet apples showing cracks and excess russeting due to frost injury. Photographed on August 1

171, Northern Spy apples broadly marked with russet on the basal half, due to frost injury. Photographed on August 1

172, Sections of apples taken immediately beneath hailstone spots such as are shown in Plate XLI, 173. Photographed on August 4



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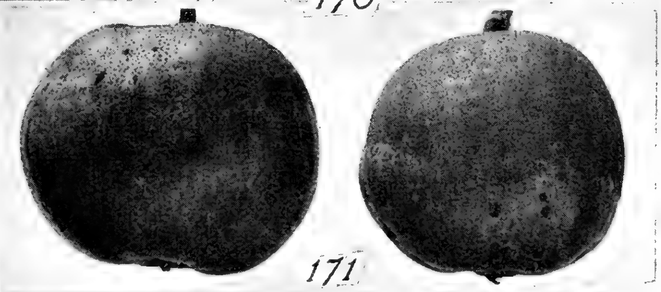

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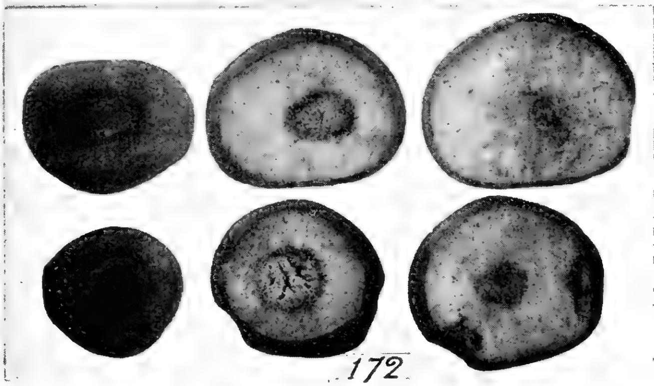

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Plate XLI

HAILSTONE INJURY

173, A Baldwin apple, injured by hailstones on July 20, as it appeared on August 4

174, A Baldwin apple which was injured by a large angular hailstone on July 20, as it appeared on August 4

175, A Baldwin apple which was badly injured by a hailstone on July 20, showing the stage of recovery that it had reached on August 17

176, An apple showing four hailstone injuries that were inflicted early in July, and one small fruit-worm scar (in center) which very much resembles them. Photographed on August 23

177, Crab apples showing several hailstone scars. Photographed on August 17

178, Baldwin apples that received several hailstone pecks, shown to be recovering when photographed on August 17

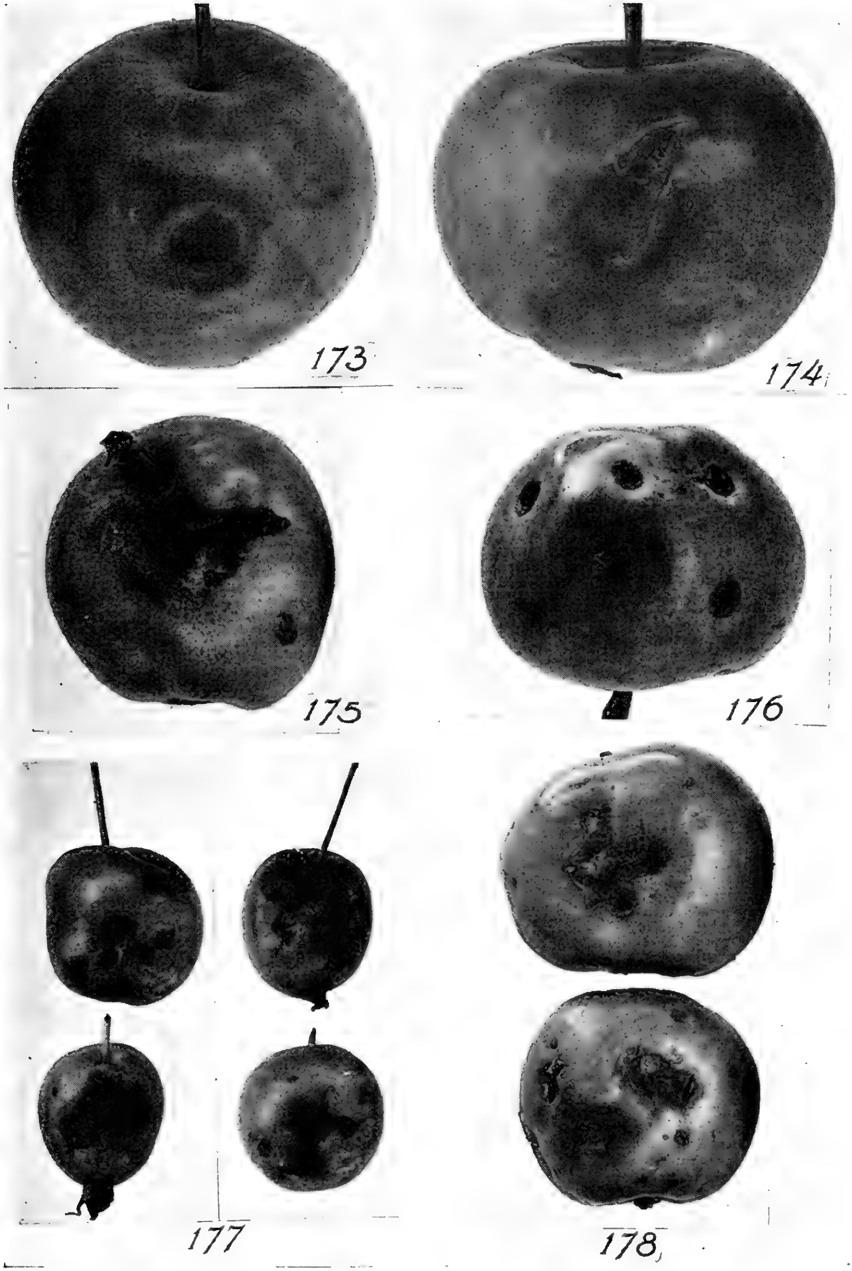
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Plate XLII

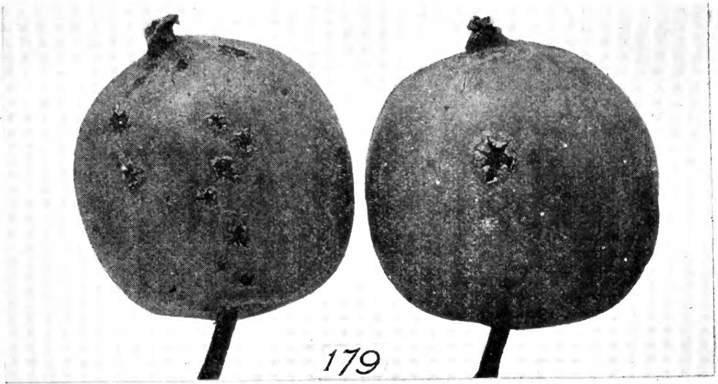
INJURIES PRODUCED BY APPLE SCAB AND STIPPEN

179, Scab spots on Rhode Island *Greening* apples, showing the papery edge which surrounds the dark central spot. Photographed on July 20

180, Excessive scab development on one side of a Rhode Island *Greening* apple. The scab caused the skin to dry out and harden, with the result that a large crack developed. Photographed on July 20

181, Rhode Island *Greening* apple showing the spots caused by late scab infection. Photographed on September 15

182, Baldwin apple in section, showing dark discolorations in the flesh where stippen has developed. Photographed on August 22



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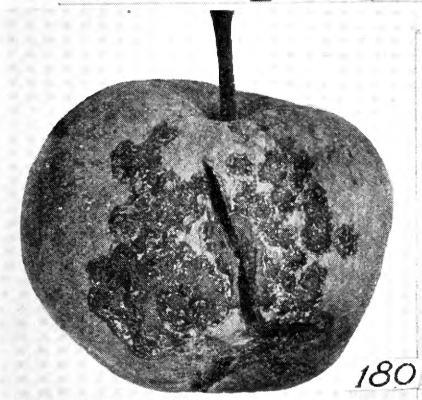

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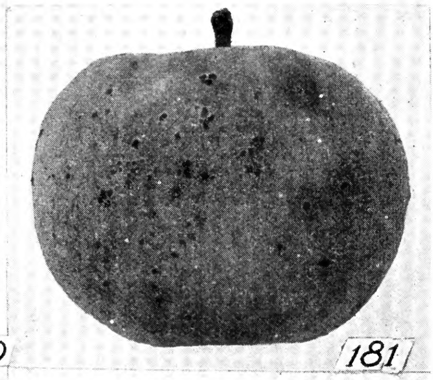

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